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PREFACE

Geography and exploration have always been closely associated with each other, so much so that in the popular mind they are almost identical. Certain influential geographical journals still devote the greater part of their space to accounts of exploration. They do so because, for a very considerable period, it was the explorer who was making geography. It was only as he pushed into the unknown that a description of the earth that merited the prefix "geo-" could be arrived at.

Most of the explorers of the nineteenth century became geographically minded as they tried to describe what they explored. Although professionally they were factors, navigators, missionaries, soldiers, or sportsmen, they acquired a geographical outlook and began to relate one thing to another in the regions through which they passed. Their interests were wide, ranging from physiography to ethnography; however, few were employed as geographers, and few if any of them ever wrote a systematic geography.

By the early twentieth century, exploring became a more scientific affair and was increasingly carried on by groups of men, each a specialist in his own field. Some of these men, with their scientific background, began to correlate one aspect of the environment with another and to note their relationship to the geographical patterns that were observed. From this they stepped into geography, and not a few of them became professional geographers. Canadian geography has been enriched by the contributions of one such explorer turned geographer, Dr. Griffith Taylor, the head of the first fully fledged geography department in the country.

The mid-century geographer, however, has rarely been introduced to geography, or received his training in the subject, in this way. He is a product of a formal course in the description of the earth. His opportunity has chiefly consisted in helping to systematize the vast amount of knowledge that the explorers over the centuries have gathered and in applying it to the problems of the day. He is related to the explorer only in so far as he has acquired the tradition of recording and testing data in the field. Although he works over well-known country, he explores new ways of analysing it and makes new descriptions of it, based on field surveys. He is no arm-chair encyclopædist.

This keeps him interested in the exploration that still remains to be done; particularly so in a country like Canada where a great part of the terrain is still unknown and not readily accessible. In his article on the changing map of Northern Canada, Professor J. L. Robinson[1] points to the numerous changes in our knowledge of that sector of the country that have occurred in the last 3 decades.

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1 Robinson, J. L.: Changing the Arctic Maps; The Beaver, December 1951, March 1952, Winnipeg.

Among the more important of these have been the discoveries in the Western Archipelago and in Foxe Basin. His map thus shows the splitting up of Borden Island into two separate islands; the division of the northeast peninsula of Victoria Island to make room for Stefansson Island; and the appearance of a group of islands in Foxe Basin, not hitherto known.

These discoveries were not made by geographers. Nevertheless, it was possible, shortly after they were made, to send in geographers who were able to explore the regions concerned by air and by sea and to increase our knowledge of them.

This number of the Geographical Bulletin is devoted to two expeditions by the Geographical Branch into the Canadian North. The one was a joint expedition of the Branch, represented by a member of its staff, Dr. J. L. Jenness, and the Arctic Institute of North America, in the person of Dr. A. L. Washburn. The other was an expedition led by Mr. Manning, then attached to the Branch, with geographers, a botanist, and a geologist.

The purposes behind the expeditions were different. That behind the Western Archipelago survey was not to take cognizance of the new discoveries as such, but rather to make a new and a geographical appraisal of an area in which much recent work had been done. Dr. Jenness has published the first part of the work he did while in the Geographical Branch in the pages of the Geographical Review[1]. It deals in the main with the landward aspects of the region. His present article complements the former by describing the geography of the seas and channels of the Western Archipelago.

The purpose of the Foxe Basin expedition was to make a ground reconnaissance of areas photographed from the air. In this case, no landings on the newly discovered islands had been made before and there were no field observations on their geology, physiography, soils, vegetation, or wild life. Unfortunately, the season did not prove either long enough or open enough for extended traverses across the islands. Nevertheless, the data gathered were valuable because of all the lands discovered since 1918 these are perhaps the most significant. In any event, an attempt was made at a geographical approach to exploration, an interesting reversal of the usual relationships between the explorer and geography.

The account in the following pages is by J. K. Fraser, who, although he himself has carried out field investigations in the Arctic, was not a member of the Foxe Basin expedition. He sums up the history of the exploration of the region and summarizes the diary of the expedition. The article also provides a factual description, including the basic data on the geography of the islands. It is hoped that subsequently an interpretation of this in relation to the geography of the whole basin and its surrounding lands will be forthcoming.

J. WREFORD WATSON,
Director, Geographical Branch

[1] Jenness, J. L.: Erosive Forces in the Physiography of Western Arctic Canada; Geographical Review, vol. 42, 1952, pp. 238-252.

THE ISLANDS IN FOXE BASIN[1]

J. K. Fraser

The search for a route to the Orient around the northern coasts of North America brought explorers into Hudson Strait early in the seventeenth century. This at first appeared to be a promising passage, but it was soon discovered by Hudson in 1610 that the strait opened into Hudson Bay and that a route out of this inland sea must be found. Button reached the western coast of Hudson Bay in 1612 and attempted to penetrate Roes Welcome Sound, which separates Southampton Island from the mainland. Foxe, in 1631, was the first to find the large body of water north of Hudson Bay that bears his name, but he managed to push only a few miles north along the west coast of Foxe Peninsula[2]. For 100 years the northern exits of Hudson Bay were disregarded, until Middleton in 1742 sailed up Roes Welcome Sound to Wager Bay and Repulse Bay and proved that no western route existed there.

In the nineteenth century the search turned more to the passages leading off Lancaster Sound, but in 1821-23 Parry entered Foxe Basin via Repulse Bay and explored the western coasts as far as Fury and Hecla Strait[3]. The coast of Melville Peninsula was mapped, and parts of the northern shore of Foxe Basin as far east as the entrance to Murray Maxwell Inlet (now Bay), but Fury and Hecla Strait was found to be impassable. This route was then abandoned for some 40 years, until Hall, in 1868, explored these coasts by land, travelling from Repulse Bay up the eastern coast of Melville Peninsula and along the southern shore of Fury and Hecla Strait to its western end[4]. Hall's journeys were made with the purpose of discovering traces of the lost Franklin expeditions, and though the trip to Fury and Hecla Strait was unsuccessful in this respect, it added considerably to the more accurate delineation of the western coasts of Foxe Basin.

It is probable that Foxe Channel was often visited by whalers from 1855 onwards, but apparently none reached the northern coast; in any event no record of such a trip has been left. Islands in Foxe Basin were unknown (except for Jens Munk Island, noted by Parry but thought by his expedition to form part of Baffin Island) until a statement obtained in 1897 from Captain John O. Spicer, an American whaling captain, was included in a Canadian government report of an expedition to Hudson Bay in that year[5]. Captain Spicer, as well as other whalers, had visited the west coast of Foxe Peninsula and wintered at "Spicer's Harbour" (probably

[1] This account is based on the reports of a Geographical Branch party, led by T. H. Manning, which carried out investigations in the basin during the summer of 1949.

[2] Christy, M. (ed.): The Voyage of Captain Luke Foxe......and Captain Thomas James....in 1631-32; Hakluyt Soc., London, 1894.

[3] Parry, W. E.: Journal of a Second Voyage for the Discovery of a North-west Passage; London, 1824.

[4] Hall, C. F.: Narrative of the Second Arctic Expedition made by Charles F. Hall....during the years 1864-69 (ed. by J. E. Nourse); Washington, 1879.

[5] Wakeham, W.: Report of the Expedition to Hudson Bay and Cumberland Gulf in the Steamship *Diana* ....in the year 1897; Ottawa, 1898.

Schooner Harbour on the present map), and during the season of 1879 had discovered a small group of low islands in Foxe Basin. He writes in his account of that voyage that on August 7 he sighted reefs and low islands, barely visible from the deck at high tide. For over 50 years these islands appeared on maps marked only with dotted lines, and they remained unreported again until MacMillan sighted them in 1921.

The east coast of Foxe Basin was entirely unknown to white men except from sketches made by Eskimos until, in 1910, a German anthropologist, Bernard Hantzsch, reached it with some Eskimos after crossing Baffin Island from Cumberland Sound. Hantzsch arrived at the coast at the mouth of Koukdjuak River and explored as far north as Piling Bay. His party was poorly equipped, game was scarce, and after a difficult winter Hantzsch died on his return to Hantzsch River. His notes were brought back to Cumberland Sound by his Eskimo companions[1].

MacMillan's expedition wintered at Schooner Harbour in 1921, and mapped parts of the coast of Foxe Peninsula. His schooner *Bowdoin* sailed into Foxe Basin, sighting the Spicers as mentioned above and exploring parts of the eastern part of the basin[2]. The eastern coast of Foxe Basin was again visited in 1925, by Soper, who travelled overland from Pangnirtung, mapping the lakes en route, and reached Foxe Basin at the mouth of Koukdjuak River[3]. Members of the Putnam Baffin Island Expedition of 1927 mapped the northern coast of Foxe Peninsula as far as Bowman Bay[4] and carried out some geological work[5]. In 1928 and 1929, Soper resurveyed parts of Foxe Peninsula and mapped the eastern coast of Foxe Basin from Bowman Bay to Hantzsch River[6].

The western coast of Foxe Basin had been unvisited since Hall's journeys in 1868, but between 1922 and 1924 members of the Danish Fifth Thule Expedition explored Melville Peninsula and crossed to the northern coast of Foxe Basin on Baffin Island, reaching as far east as Steensby Inlet[7]. In 1936, Bray and Rowley journeyed up Melville Peninsula to Igloolik and from there mapped the coast of Baffin Island as far as Piling Bay. Manning used the results of this mapping in compiling his map in the *Geographical Journal* of May-June, 1943. This map accompanied his description of the eastern and northern coasts of Foxe Basin, which he wrote from field studies made during 1939 and 1940 in this region[8].

Islands in Foxe Basin, apart from the Spicer Islands, have been discovered only comparatively recently. The Fifth Thule Expedition in 1922-24 found that Murray Maxwell Inlet was actually a bay whose entrance was sheltered by a large island, which they named Jens Munk

[1] Millward, A. E. (ed.): Southern Baffin Island; Ottawa, 1930.

[2] Letter from D. B. MacMillan to F. H. Peters, Department of the Interior, Ottawa, January 10, 1937.

[3] Soper, J. D.: Explorations in Foxe Peninsula and along the West Coast of Baffin Island; Geog. Review, vol. 20, 1930, pp. 397-424.

[4] Putnam, G. P.: The Putnam Baffin Island Expedition; Geog. Review, vol. 18, 1928, pp. 1-27.

[5] Gould, L. M. *et al.*: Contributions to the Geology of Foxe Land, Baffin Island; Mus. of Pal., Univ. of Mich., Ann Arbor, Michigan, Nov. 1928.

[6] Soper, J. D.: op. cit.

[7] Mathiassen, T.: Contributions to the Geography of Baffin Land and Melville Peninsula; Report of the Fifth Thule Expedition, 1921-24, Copenhagen, 1933, vol. I, No. 3.

[8] Manning, T. H.: The Foxe Basin Coasts of Baffin Island; Geog. Jour., vol. 101, 1943, pp. 225-251.

Island. Another island to the east was called Koch Island. Manning named Bray and Rowley Islands after the first two white men to visit or pass near them, and other islands discovered by Manning near the east coast of Foxe Basin were named after Lord Tweedsmuir, the Governor General of Canada at that time, and after R. M. Anderson, Chief of the Division of Biology in the National Museum of Canada. Some islands south of Anderson Island were noted by Manning in 1940, and appeared only as indefinite outlines on his map of 1943.

The Spicer Islands had been sighted only twice, by Spicer in 1879 and by MacMillan in 1921, and their position and size were doubtful until, in 1946, a flight was made by a Royal Canadian Air Force Canso aircraft over Foxe Basin with the specific object of establishing the existence and position of the Spicers. Flying out of Coral Harbour on Southampton Island, the aircraft located the islands a few miles to the west of their supposed position. They were found to consist of two main islands, between 10 and 15 miles in length respectively, and several much smaller ones[1].

RECENT DISCOVERY OF NEW ISLANDS

Until 1948, therefore, the eastern waters of Foxe Basin remained unexplored, and maps showed this area barren of islands. However, various accounts had included suggestions of bodies of land still to be discovered. Boas mentions that "From observations made by Captain Spicer, of Groton, Conn., and information obtained from the Eskimo, we learn that the whole of the eastern part of Foxe Basin is extremely shallow and that there are many low islands scattered about in those parts of the sea"[2]. In 1932, the Canadian Government steamer *Ocean Eagle* under Captain W. A. Poole carried out ice patrols in Hudson Bay and Strait and ventured into Foxe Basin. On September 3, Captain Poole's log reads: "Begins with moderate north wind, clear and fine. 3.35 a.m., half speed ahead steering south by compass, east true toward land sighted last night. 6.30 a.m. came to anchor in 10 fathoms about 4 miles off shore, the land appears low with many boulders on the hills and shore. The coastline was nearly straight extending about 15 miles both to the NNE. and SSW., our position at the middle part of the island lat. 67·47 N., long. 77·28 W."[3]. A note in the synopsis of the reports of that season mentions this discovery and gives the name Poole Island to the land sighted[4]. However, Poole Island was never added to the maps.

MacMillan in 1921 and Bartlett in 1927 had already navigated their vessels close to this body of land sighted by Poole in 1932. Yet neither of these captains reported any land, although ice conditions and poor visibility might easily have prevented them sighting Poole's landfall.

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1 Polunin, N.: Arctic Unfolding; London and New York, 1949.

2 Boas, F.: The Central Eskimo; Ann. Rept. Bur. Amer. Ethn., vol. 6, 1884-85.

3 Navigation Conditions in Hudson Bay and Strait during Season of Navigation, 1932; Dept. of Marine, Ottawa, 1933, p. 36.

4 Navigation Conditions; op. cit., p. 8.

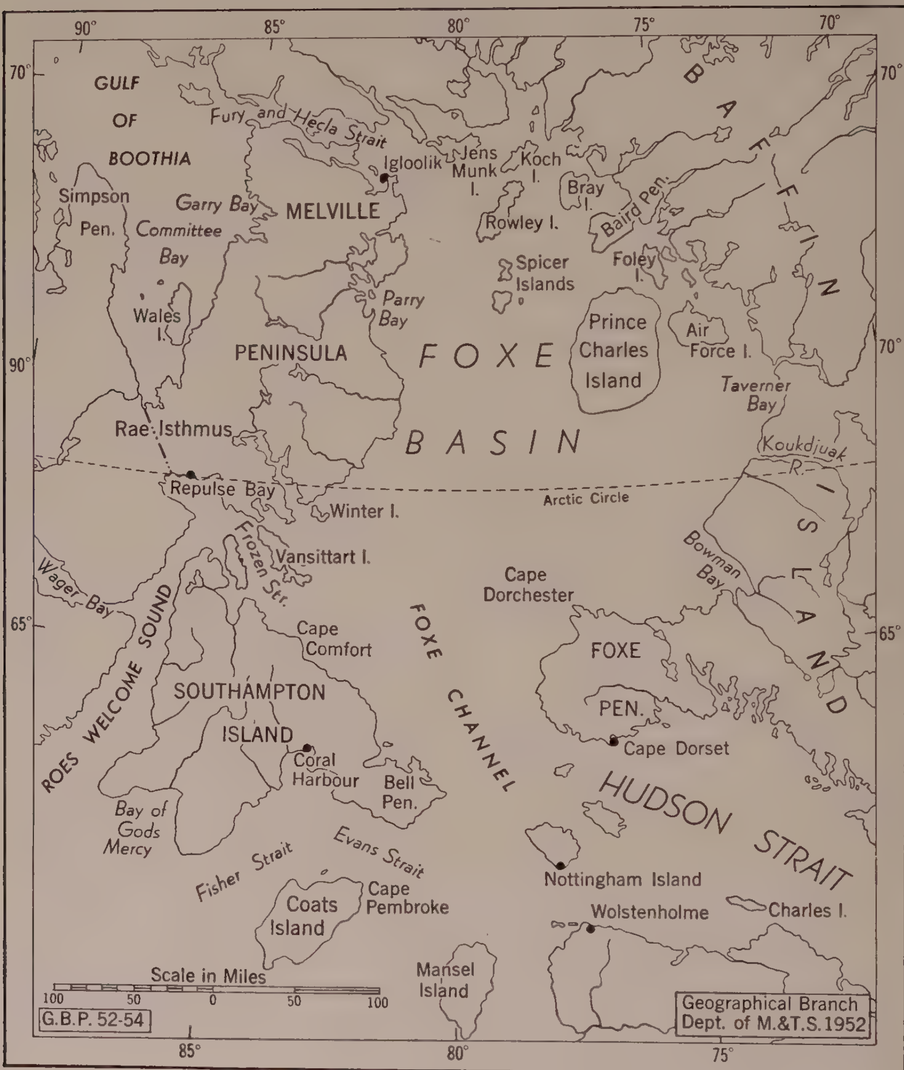

Figure 1. The islands in Foxe Basin.

In Manning's account of his explorations on the east coast of Foxe Basin in 1939-40, he wrote that the behaviour of both ice and tides in Wordie Bay suggested the probability of islands farther south than any he depicted on his map. The first time he was on Parry Point he was almost certain there was land some 30 miles due west; when he was there again, however, conditions were not favourable for observations[1]. As related, Manning also mentions islands south of Tweedsmuir Islands, and marks them on his map with dotted lines.

During the flight to the Spicers in 1946, Nicholas Polunin gained the impression that there were other low islands yet to be discovered about the shallow eastern waters of Foxe Basin. He thought he saw several during his flight, to the east as well as to the north, but owing to the distance or poor visibility he could not be sure of this[2].

It was, therefore, not too surprising when, in July 1948, the crew of a Royal Canadian Air Force Lancaster aircraft reported sighting several large uncharted islands in the eastern part of Foxe Basin. The pilot of this aircraft attached to a photographic squadron has given his account in a press article. "We were coming back above the clouds at about 15,000 feet....Through the broken clouds we noticed land when according to our charts, we should have been over water. We changed course because we thought we were on the west side of Baffin Island. By radio fix, we found that we were east of our base, so we swung back west again. After we landed, we rechecked the flight and came to the conclusion that the land we saw must be an island. We got permission from Rockcliffe to extend our photo trip to include the two new islands and we photographed them"[3].

From these photographs, a large scale (3·95 miles to 1 inch) preliminary map was compiled, which showed that the islands were of much greater extent than had been expected. Three new large islands were shown to exist, with a total area of about 6,000 square miles. The largest, subsequently named Prince Charles Island after the present heir to the throne, is approximately 85 miles in length from north to south and 75 miles from east to west. Air Force Island, to the east of Prince Charles, was named for the Royal Canadian Air Force. It is some 20 miles in length from north to south and 30 miles from east to west. A smaller island, north of Air Force Island, was at first believed to be unrecorded, but it was subsequently found that this was Anderson Island, noted by Manning in 1939[4]. This island was named after Flying Officer J. H. Foley, the navigator of the discovery aircraft, who was later killed in a flying accident. A prominent scarp on the northeast coast of this island was named Anderson Bluff, and a smaller island immediately north of Foley Island was named Anderson Island.

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1 Manning, T H.: op. cit., p. 240.
2 Polunin, N.: op. cit., p. 252.
3 Ottawa Citizen, January 22, 1949.
4 Manning, T. H.: op. cit., p. 248.

No new islands were discovered by the expedition sent into Foxe Basin the following summer, and it is unlikely that further discoveries of large bodies of uncharted land will come to light in the future. In view of the numerous and large islands discovered by Sverdrup, Stefansson, and others in the more remote areas of the Canadian Arctic in the last 50 years, it is interesting that the new islands in Foxe Basin some 900 miles farther south should have been discovered only so recently.

Several reasons account for this late discovery. The lack of game, as reported by several explorers, in the eastern part of Baffin Island has prevented permanent settlements of Eskimo, precluding the establishment of trading posts and the expansion of exploration. Ice conditions in Foxe Basin are notoriously bad, especially in summer, and this, with the shallowness of the eastern waters, has prevented many vessels from venturing far into the basin. At first, Foxe Basin and Fury and Hecla Strait as a route into and through the Canadian Arctic Archipelago were believed to be of value, but the discovery of Lancaster Sound to the north, running in a westerly direction through the islands, was found to be more useful. This latter route was utilized by numerous expeditions searching for Franklin, because the lost explorers traversed Lancaster Sound on their last voyage. Parry's expedition of 1821-23 was the only exploratory ship voyage to investigate Foxe Basin in the nineteenth century, and the only further scientific explorations by sea were those of MacMillan in 1921 and Bartlett in 1927, neither of whom reported sighting new islands in the eastern part of Foxe Basin. As Prince Charles and Air Force Islands are low-lying, they are not easily visible from shipboard or from the coasts of Baffin Island, and the surrounding shallow waters are generally filled with ice that blends with the featureless and often snow-covered islands.

THE EXPEDITION TO FOXE BASIN, 1949

The discovery of the new islands attracted public interest, as they were located in a latitude generally much better known than the northern archipelago. Foxe Basin was comparatively more accessible than the high Arctic and it was felt that an investigation of the character of the islands should be carried out as soon as possible. Moreover, before the maps of that region could be satisfactorily revised by means of the recent aerial photographs, it was necessary to obtain the positions of a number of ground control stations on the new islands, on Baffin Island, and on Melville Peninsula.

Surveys on foot would naturally be quite impractical, and flights over the area had shown the difficulties that would be encountered in attempts to land aircraft in the shallow, ice-filled waters in northern Foxe Basin. The aerial photographs indicated that few lakes were available for aircraft landings on the new islands. It was decided, therefore, to send a party by boat into the basin, and that such a party should include representatives from various branches of science. Arrangements were made

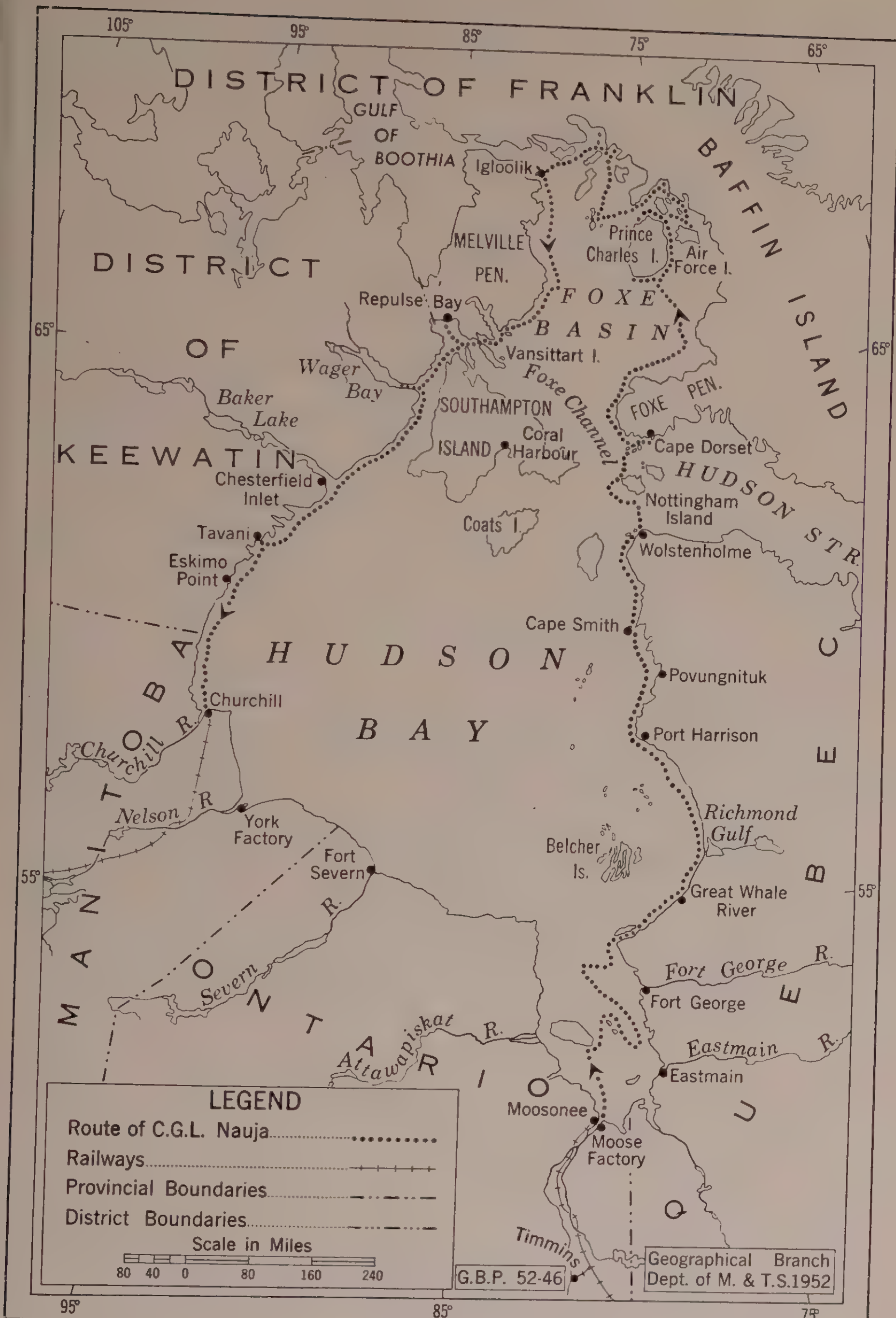


Figure 2. The route of the C.G.L. *Nauja* during the summer of 1949.

for an expedition by geographers of the Geographical Bureau of the Department of Mines and Resources, to which geodesists, geologists, and biologists would be attached. It was suggested that the party carry out geomorphological, geological, botanical, zoological, and archæological studies, establish astronomic positions, take soundings and tidal observations, and report on weather and ice conditions.

Because of the problem of navigation in early summer in the waters of Foxe Basin, where the ice is not likely to open up until August, it was planned to spend the early part of the summer in James and Hudson Bays. It was hoped to visit certain islands in these waters before reaching Foxe Basin and so carry out a useful summer's work in case it proved impossible to investigate the new islands. Plans were laid to have a suitable boat built in Nova Scotia. This was called the *Nauja*, the Eskimo equivalent for "gull". It was shipped to Moosonee in James Bay, which was to be the rendezvous and starting point for the expedition.

After visiting islands in James Bay and checking the position of Gasket Shoal, the *Nauja* travelled up the east coast of Hudson Bay, pausing at the settlements of Port Harrison and Smith Island and making short trips ashore at other points. On August 7, it visited the radio station on Nottingham Island and on August 11 four of the party were put ashore at Cape King Charles at the entrance to Foxe Channel. A report from the Royal Canadian Air Force photographic unit at Coral Harbour on Southampton Island had been received a week previously, stating that Foxe Channel was completely blocked with ice north of 64° 30′, and, therefore, the party had been in no hurry to attempt to penetrate Foxe Basin. The *Nauja* made a trip to Cape Dorset, where refuelling was carried out and the launch returned the following day to Cape King Charles with full tanks and 5 extra drums of fuel.

Exploratory work in Foxe Basin began the next day, August 13. The *Nauja* made good time after leaving Cape King Charles. Between Nuwata and Cape Dorchester loose pack-ice was encountered, but it gave no trouble and only twice had the launch to push through narrow strings with the engine. After passing Cape Dorchester more ice was sighted to the north, and the course was altered somewhat to the east. However, 20 miles east of Cape Dorchester the ice was left behind except for occasional loose strings and small pieces. A strong tidal current slowed the speed of the *Nauja* until later in the night, when the tide changed and the current became more favourable.

The launch headed for Cape Dominion, though several times course had to be altered to avoid stretches of pack-ice. Eventually, the expedition found itself about 4 miles off Cape Dominion and course was altered for Prince Charles Island. Loose ice forced the *Nauja* to keep to the east, but by 1100 hours on August 14, the ice was left behind and a fair wind enabled the sail to be raised. Later in the afternoon the wind had increased considerably and a short stop was made to relash the deckload,

which had begun to shift. Prince Charles Island was sighted ahead at 1840 hours just as a heavy rain began to fall. An attempt was made to find shelter in a small bay, but it was found to be too shallow and finally the launch was anchored a mile or so offshore in 21 feet of water. This was the longest run of the summer, a little over 300 nautical miles in less than 41 hours.

The southern shore of Prince Charles Island has no distinctive features by which the *Nauja's* position could be fixed but it was assumed that she was anchored near the southeast point of the island. Accordingly, anchor was weighed when the weather cleared somewhat and the launch proceeded to the westward. The low coastline could occasionally be seen through the light fog, but the bottom was so level and shelving that the

Figure 3. Boulder-strewn marshes about 1 mile inland from Gravell Point, Prince Charles Island.

distance from the land could be gauged by the readings on the echo sounding apparatus. Finally a small point near the southwest point of the island was identified from the aerial photographs and it was decided to make a landing and attempt to establish an astronomic position. This was eventually named Gravell Point.

The shore party was quickly landed at a small beach near the point (Figure 3) and the *Nauja* moved into deeper water. It was expected that there would be a considerable range of tide here, as at Hantzsch River, 120 miles to the east, Manning had found a rise and fall of about 25 feet[1]. Observations, however, showed a range of only about 3 feet, and it was

[1] Manning, T. H.: op. cit., p. 245.

possible to move the boat closer to land, finally anchoring about a mile from shore. Nevertheless, there was no shelter except from the north and that which was afforded by the somewhat shallower water in other directions.

PRINCE CHARLES ISLAND

From short explorations inland, observations were made on the physiography of the southern part of Prince Charles Island. Shallows extend for some distance off the coast, drying for a few hundred yards at low tide. The beach consists of limestone fragments backed by boulder-strewn storm flats of grass and mud. The shoreline is much sculptured by the sea, which has formed numerous spits, apparently in places the remnants of former shoals. A series of abandoned beaches of sand, gravel, and angular disintegrated limestone fragments, separated by shallow brackish lagoons near the coast and grassy meadows and shallow sloughs farther inland, form the terrain for several miles from the coast. Still farther inland, the country is a flat plain, partly covered with small lakes and ponds. This plain rises only some 10 feet above the sea and is composed mainly of limestone fragments covered in places by sedge and grasses. Drier tundra continues to the north, with a few small gravel hills rising about 8 feet above the tundra and not more than 20 feet above the sea.

No outcrops were found along the south coast, but poorly preserved fossils found in the limestone rubble were plentiful and were mainly of Ordovician age.

The shore party returned to the *Nauja* late in the evening of August 18, because bad weather appeared to be approaching from the west and it was advisable to move from this exposed anchorage. It had been hoped to proceed northwards along the west coast of Prince Charles Island, but radio reports of ice in this area had been received and the weather would have made it necessary to travel with an onshore wind, which would probably have blown ice against the island. The *Nauja*, therefore, proceeded along the south coast of Prince Charles Island to the east and turned north through Cockram Strait, which separates Prince Charles from Air Force Island. Off the northern coast of Prince Charles Island the water is quite shallow, with numerous boulder shoals, on one of which the *Nauja* grounded. It was necessary for members of the expedition to stand in the bow while the engine was put full ahead in order to slip over this shoal. Late that evening they anchored about a mile off the northwest point of Prince Charles Island, which was named Outcrop Point because of a small cliff of exposed limestone. The anchorage was exposed to all winds except from the south. Ice had been encountered in small quantities in Cockram Strait, but heavy pack was seen to be lying about 10 miles to the north and west of the anchorage. The shore party was landed, and by the afternoon of the following day a position had been established and short explorations made; the expedition then proceeded to the east before the heavy ice began to close in from the north.

This promontory on the north coast of Prince Charles Island is not typical of most of the coastline of the island. It is formed by non-fossiliferous, horizontally bedded limestone, which outcrops along the shore in a cliff 4 or 5 feet high. It is probable that this location is the highest and driest part of the coastline; however, at low tide there is a quarter of a mile of tide flat composed mainly of large angular pieces of limestone. Above the low cliff, a rather flat plateau of disintegrated limestone fragments and erratic boulders over dry tundra extends some miles inland. A few shallow small lakes are scattered across this plateau. Immediately west of the point is a shallow bay with extensive mud flats fringed by boulder-strewn grass, which is followed by long grass meadow. Abandoned beaches follow the coast a short distance inland.

Prince Charles Island probably does not anywhere rise over 100 feet, and no large lakes are shown on the aerial photographs. The largest lake is not more than 10 miles in length. Old strand lines or possibly moraines in the interior of the island may be noted on the aerial photographs. The low character of the whole island has prevented the eroding of stream valleys to any great depth; the drainage system is not strongly established and most streams probably dry up during the summer (Figure 5). A chain of narrow lakes has been formed in the northern part of the island at the base of what appears to be a strongly formed abandoned shoreline. The greater part of the surface of the island is probably of reworked glacial deposits, mainly sands and gravels, with areas of rough limestone fragments.

The *Nauja* expedition reported that numerous caribou were seen near their landing on the southern coast of Prince Charles Island (estimated as about one caribou per square mile), but none was seen on the northern coast. A polar bear was encountered and shot on the south coast and others were seen on the north coast. Walrus bones were numerous on the south coast. Varying lemming were plentiful on the south coast, but only one was seen on the northern coast.

Bird life was noted at all stopping points, but as Foxe Basin was only reached in mid-August, the migration of most species had already begun and it was difficult even to estimate the number of species that had nested there. Birds were more plentiful on the south coast, where more meadow exists than around the rocky peninsula on the northern coast. Species identified on Prince Charles Island were Pacific loon, red-throated loon, American brant, old-squaw, king eider, rock ptarmigan, golden plover, black-bellied plover (probable), Hudsonian curlew (possible), purple sandpiper, white-rumped sandpiper, semipalmated sandpiper, red phalarope, parasitic jaeger, long-tailed jaeger, glaucous gull, herring gull, Sabine's gull, Arctic tern, horned lark, American pipit, Lapland longspur, and snow bunting. It was not definitely established that all of these birds nested on Prince Charles Island, but certain species were noted with young.

The *Nauja* crossed the northern end of Cockram Strait, rounded the northern point of Air Force Island, and anchored in the good shelter that was named Nauja Harbour (Figure 4). Most of the trip was made under conditions of poor light, but by the use of the depth recorder a way was found into this harbour where there was shelter from all westerly and southerly winds. This was fortunate, for the next morning a strong westerly wind was blowing and the former anchorage off Prince Charles Island would have been exposed to pack-ice moving on-shore. It was also a pleasant change to anchor close to shore and to be able to take the canoes ashore at all tides.

Figure 4. Looking northeast towards Nauja Harbour, Air Force Island.

Snow and rain restricted the work at this location, but during the next 4 days an astronomical control point was established, a trip was made by canoe along the east coast of Air Force Island, and several short traverses were made inland from Nauja Harbour.

AIR FORCE ISLAND

Air Force Island is considerably smaller than Prince Charles Island, but most of it exhibits the same type of low flat surface of beach gravels and reworked glacial deposits. A ridge of granitic gneiss, however, provides a break in the topography. It forms Fee Peninsula, which rises about 40 feet above the sea and stretches in a southerly direction to about the centre of the island, where it attains a height of some 250 feet. This Precambrian

inlier juts up through the flat-lying limestones and the thin overburden of glacial and marine sediment. Between these hard rock ridges the depressions are filled with grassy marsh, remnants of the till overburden, and granite and limestone boulders.

The coasts of the island, except for the northern peninsula, are extremely low and slope quite gently into the sea. There is a wide tidal belt along the shores, the surface of which is composed mainly of reworked glacial deposits with limestone slabs or fragments of all sizes up to 12 to 15 feet in diameter. At high tide, shoals and small islands are formed in this tidal belt and sedges and grasses grow on the minor elevations. Inland, the tidal belt becomes drier as the effect of the sea lessens, but still retains its character as a boulder-strewn plain. At about a half mile inland the pools contain fresh water, and the vegetation is a solid grass and sedge meadow with numerous tiny ponds and swamps.

The Precambrian ridges at the north end of the island show up well from some 30 miles and, in fact, it was this prominence that Manning noted in 1940 from the Baffin Island coast as appearing to be a small isolated island[1]. From the top of the ridge forming Fee Peninsula, a view of the Baffin Island coastline to the east could be plainly seen.

Inland from the southern and western coasts of Air Force Island lie strings of small interconnected lakes running parallel with the coast. They are presumably formed behind low abandoned strand lines created by the rising of the island in post-glacial times. Drainage in the centre of the island is nowhere strongly established, and numerous shallow lakes dot the landscape, the largest being about 2 miles across. The part of the island inland from the eastern coast does not exhibit the strings of interconnected lakes such as are found on the western and southern parts, but rather the drainage appears to flow in an unbroken pattern directly to the sea. This slope, therefore, exhibits the monotonous striped appearance characteristic of low slopes of undifferentiated sediments or till, the pattern resulting from vegetation swales rather than definite valley cutting by streams.

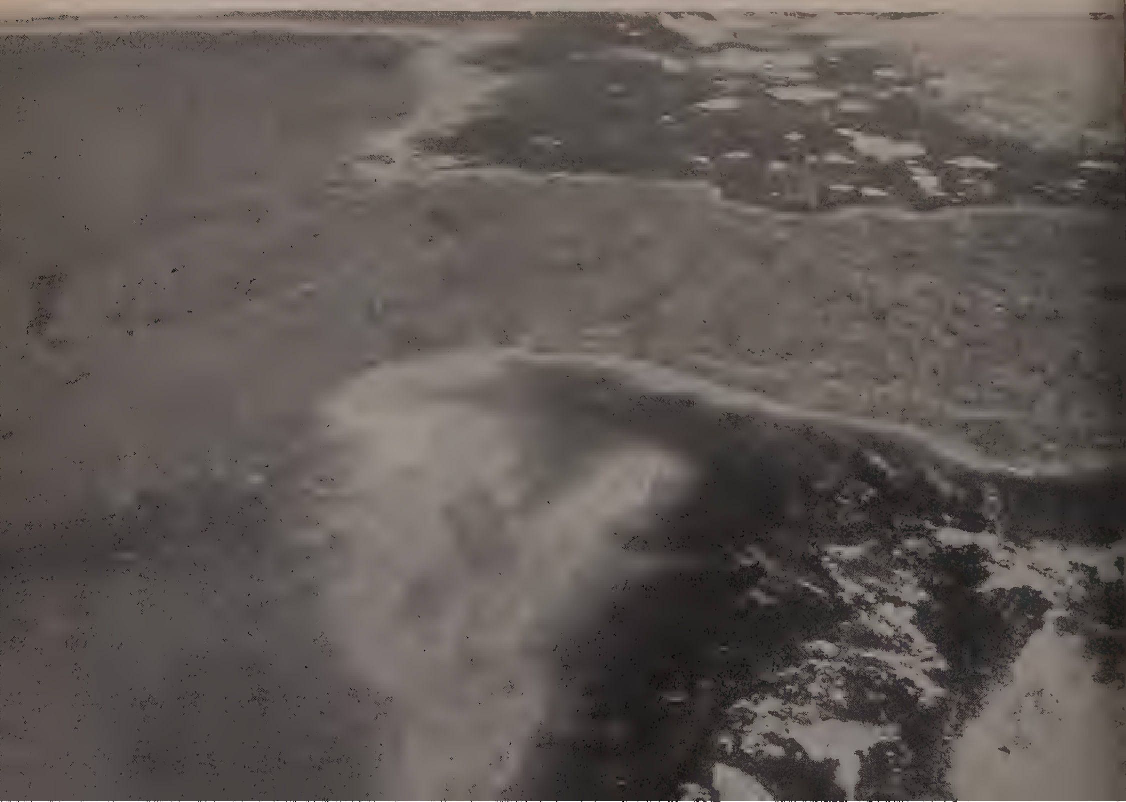
Unfossiliferous (?) limestone outcrops are found a few miles south of Nauja Harbour along the east coast of Air Force Island. These beds apparently extend east and north under the sea and form the floor of Foxe Basin in this area. The outcrops are not striking and do not form prominent features of the topography (Figure 6).

The expedition's camp at Nauja Harbour was established on the east side of Fee Peninsula about 5 miles southeast of the northern tip of the promontory. The Precambrian ridges forming the base of Fee Peninsula rise over 50 feet above sea-level about a mile from the coast. At the campsite, rocky hummocks of granite or gneiss outcropped on a flat, boulder-strewn, wet, grassy plain, which became narrower to the north as the Precambrian ridges approach the coast. Rock outcrops south of the camp

[1] Manning, T. H.: op. cit., map.

Figure 5. Looking east from central part of Prince Charles Island, showing the low featureless terrain. Air Force Island is in the background. (RCAF photo.)

Figure 6. Nauja Harbour, Air Force Island, showing Precambrian outcrop. (RCAF photo.)



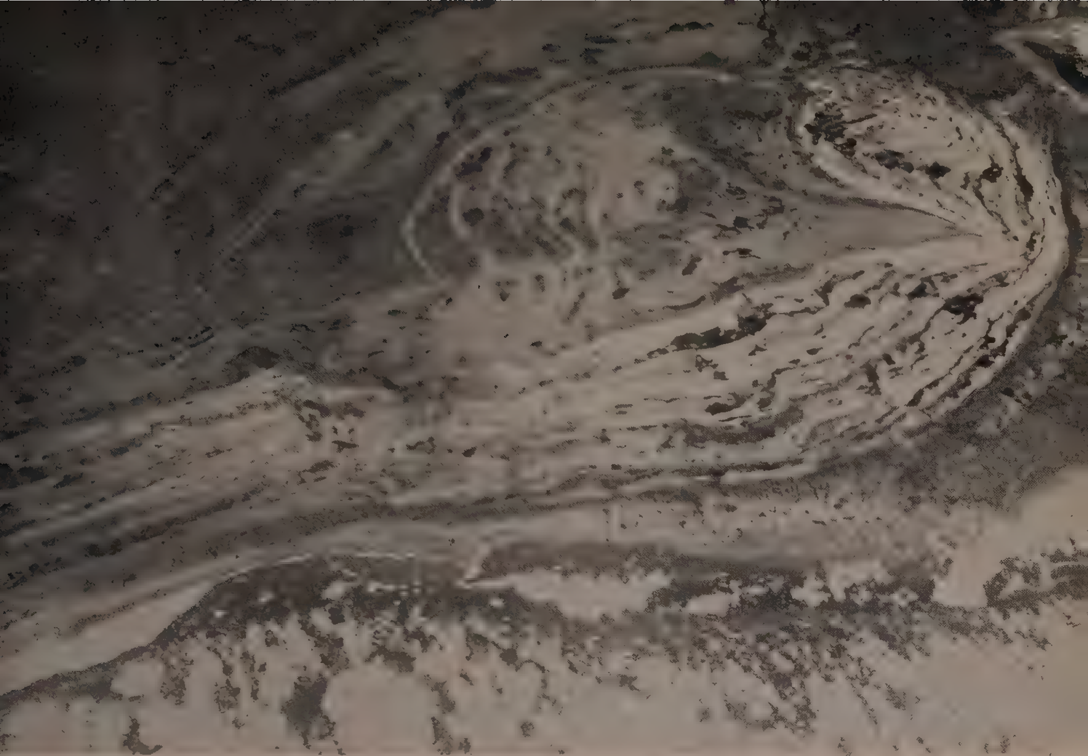


Figure 7. Anderson Bluff on Foley Island. (RCAF photo.)

Figure 8. Tideflat Bay, Rowley Island. (RCAF photo.)

were much fewer and the rocky coastline changed to a tidal flat of mud and boulders. At the camp location, small bays with steep beaches and kelp-covered boulders gave way a short distance inland to the marsh and hummock terrain.

Specimens of varying lemming and ermine were obtained near the camp on Air Force Island. Caribou tracks were seen on the north coast, and about ten carcasses, mostly of fawns, were noted during a walk nearly to the centre of the island. Manning believes that caribou may regularly cross between the islands and Baffin Island over the ice in winter.

Species of birds identified on Air Force Island included the red-throated loon, the smaller snow goose, old-squaw, king eider, gyrfalcon, pomerine jaeger, parasitic jaeger, herring gull, Arctic tern, snowy owl, and American pipit. White-rumped sandpipers were very numerous. Many American brant were seen among the marshes and golden plover were observed on the lower marshes and Lapland longspurs on the tide flats. The purple sandpipers observed probably do not nest on the islands, and most of them had moved south by the time they were noted by the party. Snow buntings were found on rocky ridges, having probably migrated from the north.

On August 28, the *Nauja* left the anchorage at Air Force Island and proceeded up Clarke Sound between Baffin Island and the Tweedsmuir Islands. Two of the party were put ashore at the north end of Foley Island, two others on Baird Peninsula, and the launch continued to an anchorage off Longstaff Bluff near the entrance to Piling Bay. Manning had been on Anderson Island in 1940, when he had thought that Foley Island was part of Anderson Island. The latter name has now been restricted to the smaller northern island, and the limestone cliff on the eastern coast of Foley Island is now named Anderson Bluff.

TWEEDSMUIR ISLANDS

The Tweedsmuir Islands, composed of two large islands, 9 and 14 miles in length, and several islets, parallel the coast of Baffin Island north of Air Force Island and are separated from Baffin Island by Clarke Sound. They were first discovered by Manning in 1940, when he stated that they appeared to be composed of rocks similar to the Baffin coast, which is made up of red granite and gneiss, apparently mixed with altered sediments and volcanics[1].

South Tweedsmuir Island rises to some 400 feet above the sea, the shoreline being solid rock or gravel and shingle beach, except at the northern end where a low boulder beach is found. The island is almost entirely barren of vegetation, both on the beaches and on the higher elevations; these higher elevations exist mainly in the northern half of the island, where a ridge of smooth barren granite or gneiss rises abruptly a short distance inland from the east coast. Elevated beaches are found up to 60 feet above the present shoreline.

[1] Manning, T. H.: op. cit., pp. 239-240.

Shoals and small islets separate the two large Tweedsmuir Islands. An island about 5 miles long lies a mile south of South Tweedsmuir Island. It is entirely barren and has a shoreline varying from solid rock to gravel and shingle beaches. Aerial photographs of this island show a definite cross-jointed pattern in the bedrock, probably accentuated by continental glaciation.

North Tweedsmuir Island is more uniformly rocky than South Tweedsmuir Island, and rises to a maximum elevation of 400 feet. The granitic rocks extend into the sea in low peninsulas, especially on the east, between which are small bays with pebble and gravel beaches. The island appears mainly bare of vegetation and has the typical glaciated appearance of hard igneous rock in this area. Few lakes of any size can be found, the largest being only about a half mile in length, and they are found almost without exception along the foot of the ridge that forms a prominent feature along the north and east coasts of the island. The western shore of North Tweedsmuir Island is more regular than the eastern, and the foreshore varies from quickly deepening water at the southwest to more gradual shoaling from a wider tidal belt at the northwest. Cross-jointing is apparent on the elevated, barer parts of the island, and the poorly established drainage system has utilized the glacially deepened jointings in the bedrock. It is possible that flat-lying limestone may overlie the Precambrian rocks at the northern tip of the island.

FOLEY ISLAND

West of the Tweedsmuir Islands lies Foley Island, about 32 miles in length from north to south and 14 miles across at its widest point. It is separated from North Tweedsmuir Island by a channel of only 2 miles, and from Prince Charles Island to the south by 9 miles of water. The island rises no higher than about 280 feet above the sea.

Foley Island is composed mainly of Palæozoic sediments, probably limestones of Ordovician age, but the northeastern corner of the island appears to be formed of Precambrian gneisses. Limestone scarps face the north and east, and from the sea stand out as the prominent landmark named Anderson Bluff (Figure 7). A series of abandoned beaches line the east coast, rising against the lower edges of the scarp that bounds the inland plateau sloping to the south and west. The surface of this plateau is composed of reworked glacial till and marine deposits and has many small lakes with no well-defined drainage pattern. The formation of lagoons contained by strand lines is not as evident as on Prince Charles Island.

The eastern coast of Foley Island rises from the sea rather more abruptly than does the western coast. The tidal zone, consequently, is not as wide, nor do the foreshore shallows extend as far into the sea. The southern part of the island, however, is particularly low and flat and the southeastern coast appears more indented than the rest of the coastline of the island. The west coast of Foley is lower than the east coast and

offshore shallows extend a considerable distance into the sea. Abandoned beaches here contain shallow, narrow lagoons. The larger lakes on the island are in the north-central part and the largest is about 3 miles long.

A small island off the northeast coast of Foley Island is composed of bare Precambrian gneissic or granitic rock and is joined by a narrow spit to Foley Island where Precambrian rocks form a small part of the coastline. The shoreline of this small island is low and rocky, with numerous large Precambrian boulders.

ANDERSON ISLAND

North of this small island lies Anderson Island, about 5 miles in length, which is estimated to rise some 200 feet above the sea and is composed entirely of Precambrian granitic or gneissic rock. Beaches such as those on adjacent Foley Island are not apparent on aerial photographs and the surface of Anderson Island appears similar to the Tweedsmuirs, having a jointed and polished appearance. These islands are presumably similar in structure to the Baffin Island coast and thus are geologically different from the larger islands in Foxe Basin. The channel separating Anderson Island from Foley Island appears deep, and except for a few shoals is probably navigable when free of ice.

The *Nauja* party visited Baird Peninsula and Piling Bay, where geological work was carried out and some zoological specimens were obtained. Most of the plants had finished blooming and little more collecting was possible for the rest of the voyage. Wind and rain confined the party for several days, and after a satisfactory astronomic fix was obtained the *Nauja* left for the Spicer Islands early on September 5. After some 7 hours, land was sighted and eventually identified as the north coast of South Spicer Island. Shallow water prevented approaching closer than several miles, and after passing through a field of light pack-ice with no difficulty and navigating several shoals the *Nauja* was finally anchored about three-quarters of a mile from shore in a small bay on the east coast of North Spicer Island. Here an astronomic fix was obtained during the one night ashore at this poorly sheltered anchorage.

SOUTH SPICER ISLAND

The group of islands known as the Spicers lies in the north-central part of Foxe Basin about 45 miles west of Prince Charles Island and about 65 miles east of Melville Peninsula. It is made up of two main islands, North Spicer and South Spicer, and several smaller ones, of which only one, Era Island, bears a name.

South Spicer Island is roughly circular in shape, being approximately 10 or 12 miles in diameter, and is separated from North Spicer Island by a shallow strait 6 miles across. The surface is composed mainly of disintegrated limestone and the island rises very gently from a very shallow

foreshore backed by extensive tidal flats strewn with boulders. Lines of abandoned beaches rise from this tidal zone and contain narrow lagoons behind the ridges of gravel. The beach deposits appear to extend inland almost to the centre of the island, which is so low that the plateau surface found on most of the Palæozoic islands in Foxe Basin is lacking. The coastline does not include any indentations suitable for shelter for a vessel such as the *Nauja*. Low marine plains stretch inland from the tidal zone to the lowest beach levels and most of the island appears to be composed of strand line material.

The beaches are particularly well defined along the northeast coast. Shoals are found offshore, and in some cases are not connected by spits or under water extensions to the island. The beaches rise from the east coast in fairly regular steps until near the centre of the island where they have been eroded and reworked until their continuity is quite broken. The west coast exhibits similar strand lines with numerous swamps and ponds in the intervening depressions. The tidal zone on the west coast is made up partly of bars and beaches still in the process of formation, which has resulted in a shallow foreshore adjoining a bar and lagoon complex. This coastline on the southwest part of South Spicer Island exhibits perhaps the most intricate pattern of any of the Foxe Basin islands.

Era Island lies 5 miles to the east of South Spicer Island and is only about 4 miles long. It is extremely low and flat, and the surface is probably quite swampy behind the several levels of abandoned gravel beaches.

NORTH SPICER ISLAND

Seventeen miles of water separates North Spicer Island from Rowley Island to the north. The island is about 15 miles long and is almost separated into two parts by Skelton Bay, which forms an indentation on the east coast and is separated from another bay on the west coast by a low, narrow isthmus. The northern part of North Spicer Island is extremely low and has an extensive expanse of tidal flats. A shallow foreshore changes gradually to swamp and many small ponds, and apart from an incipient beach line near high-water mark, no raised beaches are found on this part of the island. The strand lines so characteristic of the Palæozoic islands in Foxe Basin begin south of Skelton Bay, but are fewer and less well defined than on other islands. There are a great many lakes and ponds in the interior of the island, where remnants of the abandoned beaches are still visible and probably about 40 per cent of the surface is covered with water. The remainder is about equally divided between swamp or meadow and well-worked limestone rubble.

Birds noted by the *Nauja* expedition on the Spicer Islands included Pacific loon, red-throated loon, king eider, purple sandpiper, white-rumped sandpiper, parasitic jaegar, Herring gull, black guillemot, Lapland longspur, and snow bunting.

Although bearded seal were sighted in the waters between Piling and the Spicers, no land mammals were seen on the Spicer Islands. It is Manning's belief that lemming have not yet colonized these islands and that caribou have not lived on the Spicers for a long time, if ever. His conclusions are based on the fact that no evidence of lemming burrows or runs were noted by the *Nauja* party and that reindeer moss growing on North Spicer was luxuriant and yet so scarce on the island that it would undoubtedly have been cropped by caribou. He states that perhaps half of the surface of Baird Peninsula, where numerous caribou were sighted, is composed of grass meadow, whereas on the Spicers and Rowley Island only a very small proportion of the otherwise barren landscape was covered with vegetation suitable for caribou.

On the National Topographic series map Foxe Basin North (revised 1946), an unnamed island is shown lying between the Spicers and Rowley Island. This body of land is actually part of Rowley Island, which extends farther south than had been realized by Polunin[1].

The *Nauja* left the Spicer Islands anchorage early on September 6 amid snow squalls and a strong westerly wind. Close patches of fairly heavy pack-ice were passed, but offered no obstacle to navigation as there was much open water. Rowley Island was sighted at 1100 hours and its east coast was followed as far as a shallow bight subsequently named Tideflat Bay. Here a shore party set up camp on a small beach and the *Nauja* was anchored outside the bay about 2 miles from the camp in some 13 feet of water at high tide. Grounded ice nearby became a hazard by dawn when a westerly gale caused the anchor to drag and the *Nauja* was moved into Tideflat Bay into the lee of a gravel spit near the camp and allowed to ground on the flat limestone bottom as the tide fell. The launch finally was left completely high and dry, and though lying with an uncomfortable list, it was possible to inspect the bottom and try to carry out certain repairs. Ashore, the ground was covered with snow from a fall the previous night, and an inch of ice had formed around the edges of the small lakes near the coast.

ROWLEY ISLAND

Rowley Island lies about 15 miles north of North Spicer Island and about 8 miles south of Koch Island. It stretches about 46 miles in length in a direction a little east of north and its widest point is not more than 15 miles across. The island is low and flat, of Palæozoic origin, and apparently nowhere rises over 200 feet above the sea. A small outcrop of limestone was found near Tideflat Bay, but the surface of the plateau that is found inland is mainly disintegrated limestone fragments and reworked glacial deposits. Numerous lakes occur on the plateau, the largest being no more than 4 miles long, and the drainage pattern appears immature and affected by glacial action and subsequent stages of submergence and uplift. The low altitude of the island has prevented strongly incised stream

[1] Polunin, N.: op. cit., p. 250.

valleys and the inland lakes are for the most part shallow and with no definite connections and outlets shown on aerial photographs. Abandoned beaches parallel the coast and retain narrow lakes behind the beach deposits. On the northeast, the old beaches are strongly defined and rise rapidly from a shallow foreshore. The beaches are breached by several small stream valleys, which drain rather deeper lakes than are usual on this type of low Palæozoic island. Beaches also exist inland of these strand line lakes and bound this interior plateau of till and limestone fragment surface. The northern quarter of the island is almost separated from the remainder of Rowley Island by a depression marked by two indentations, the eastern one being Tideflat Bay (Figure 8), and by a large lake separated from the bays by low ridges and presumably draining to both inlets by very small streams or through rocky and grassy swamps.

The abandoned beaches are composed of gravel and limestone rubble. They extend well inland on the island and also parallel the depression mentioned above. Tidal flats extend for more than half a mile from the present high water mark and are composed of flat-lying bare limestone or limestone fragments. The bays at the ends of the depression across the island dry almost completely at low tide.

Mammals noted on Rowley Island were few in both number and species. Arctic foxes appeared to be common and there were signs of polar bear. No lemming were obtained owing to a heavy snowfall that covered the traps, but evidence suggested that lemming were as numerous on Rowley Island as on the other larger Foxe Basin islands. Eskimos state that caribou at one time roamed the island, but that a thaw that crusted the snow and prevented them from reaching their food resulted in their disappearance.

Birds observed on Rowley Island included American brant (flying), snow goose (flying), old-squaw, king eider, duck hawk (flying), red phalarope, parasitic jaeger, Herring gull, Arctic tern, black guillemot, snowy owl, Lapland longspur (about 100 in one group feeding on a frozen, partly snow-covered grass marsh near shore), and snow bunting.

At dawn on September 9, the shore party came aboard and the *Nauja* left this unpleasant anchorage. Open water was found on the run across to Ignerit Point on Baffin Island, where a suitable anchorage was found in the bay west of this point.

BRAY ISLAND

After leaving Rowley Island, the course taken had carried the launch north of Bray Island, which was not visited. It was observed to be another low, flat island, composed most probably of limestone, but covered with snow at the time of observance. There is little difference in its length and width, being approximately 26 miles from the northeast point to the southwest coast. It lies about 5 miles from the coast of Baffin Island. Further details may be noted from a study of the aerial photographs.

Figure 9. South part of Bray Island, showing the abandoned beaches, tidal flats, and lake pattern. (RCAF photo.)

As on the other low islands in Foxe Basin, a series of abandoned beaches parallel the coast almost completely around Bray Island. Large lagoons or lakes are confined inside of these beaches and several lakes up to 5 miles in length are found in the interior of the island. The surface deposits, which are almost certainly of reworked glacial till and limestone fragments, appear to have a north-northeast trend or pattern. It is probable that the island is not much over 100 feet above the sea at any point. The southern third of Bray Island has very few lakes and the abandoned beaches are found much farther inland than in the northern area (Figure 9). The foreshore of the whole coast is extremely shallow and the tidal zone appears to extend for a long distance offshore.

At Ignerit Point, the party spent 3 days attempting to establish an astronomic position, working on the engines, collecting and preparing zoological specimens, and writing up observations. Wind and snowstorms hampered operations, and on September 13 it was decided to leave without having obtained a satisfactory astronomic fix. Radio reports had stated that Frozen Strait north of Southampton Island was blocked by ice and that the Hudson's Bay Company supply vessel *Fort Severn* had given up the attempt to reach the post at Igloolik. Therefore, it appeared that it might be necessary for the *Nauja* to cross Foxe Basin to Foxe Peninsula, a hazardous trip so near freeze-up time.

The *Nauja* travelled from Ignerit Point to Cape Jensen and from there to the north coast of Koch Island, where a landing was made to examine a cut gravel beach that appeared from offshore to be a limestone outcrop.

KOCH ISLAND

Koch Island is probably composed of limestone, although the sea bottom off the northern coast appears to be Precambrian, and half a mile to the north a small island of gneiss is connected by a shoal to Koch Island. Aerial photographs show that Koch Island is quite similar in construction to Rowley Island 8 miles to the south. Abandoned beaches parallel the coasts and extend inland almost to the central part, which is lower than the plateaux of the other large islands in Foxe Basin, rising only some 80 feet above the sea. The island is a little over 30 miles in length and has two bights on the northern coast that probably dry at low tide. Tidal flats extend for a considerable distance offshore. Lakes are few in number and the largest is only about 2 miles long. The beaches at the head of the small bays on the Koch Island coastline are mainly gravel and boulders, whereas the headlands are composed of boulders and solid rock outcrops.

Crossing to the south coast of Jens Munk Island, the *Nauja* was anchored for a few hours to allow some members of the party to go ashore, where a few fossil specimens were obtained and some old Eskimo ruins discovered. The *Nauja* then proceeded to better shelter under the Calthorpe Islands, where anchorage was made for the night.

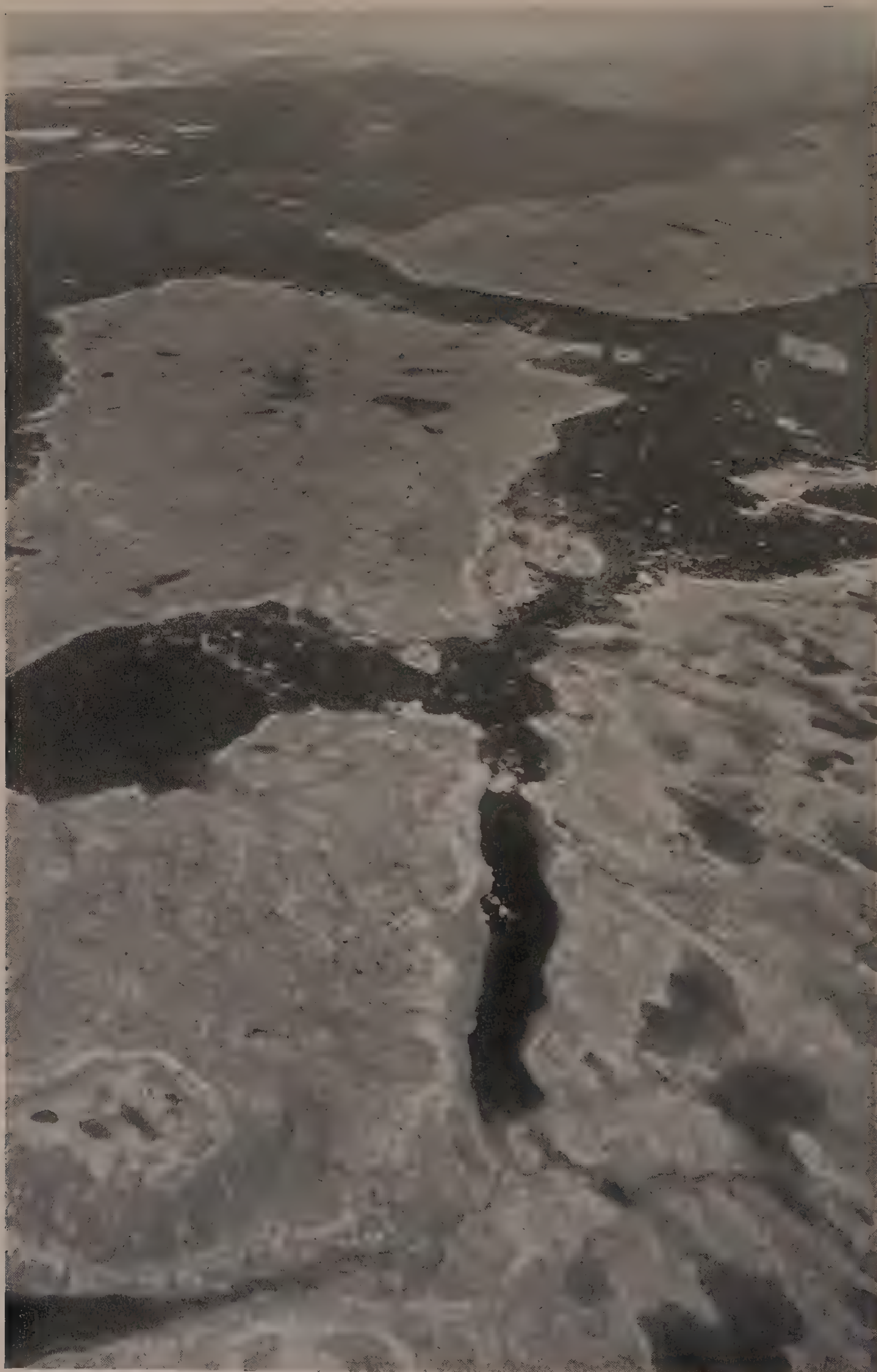


Figure 10. Jens Munk Island, showing the Precambrian part in the northwest corner and the limestone plain in the foreground. (RCAF photo.)

JENS MUNK ISLAND

The coastline of Jens Munk Island is made up of peninsulas and indentations to a greater extent than any other of the Foxe Basin islands. Formed partly of Precambrian lowlands and partly of limestone plateaux, Jens Munk Island stretches about 40 miles from east to west and varies from 14 miles to 5 miles in width from north to south. It is separated from Siorarsuk Peninsula on Baffin Island by a 2-mile wide strait and by a wider though more shallow channel at the eastern end of Murray Maxwell Bay. Jens Munk Island bars the mouth of this large bay so that entrance is afforded only by the two narrow straits between the eastern and western ends of the island and the shores of Baffin Island.

Jens Munk Island may reasonably be divided into two types of terrain. The western third of the island, almost separated by Skeoch Bay and a chain of lakes extending to a narrow inlet on the northern coast, is formed of Precambrian intrusives such as make up the adjacent coast of Baffin Island (Figure 10). To the east, the island appears to be composed of Palæozoic limestones forming a number of plateaux that rise to some 500 feet above sea-level and in places drop steeply to the sea. Tidal shallows and shoals are much more predominant around the limestone coasts than along the coast formed by Precambrian rocks. The surface of this western part is low, the relief moderately rugged, with a predominance of bare rock exposures. The abandoned beaches are not particularly noticeable except close to the coast, where due to a lack of beach material they are probably defined by rock terraces and nips rather than by residual material. Skeoch Bay forms the boundary between the Precambrian and Palæozoic formations on the Jens Munk Island southern coast and is probably the result of faulting accentuated by continental glaciation deepening.

The eastern part of Jens Munk Island is composed of limestone, with many abandoned beaches extending inland for considerable distances and bounding the higher plateaux in the central part of the island. A great many large lakes help to differentiate this plateau country from the more rugged terrain in the western part of the island. Limestone shingle and gravel beaches are found along the shores adjoining offshore shallows and connected shoals. This narrow coastal plain gives way inland to the series of abandoned beaches and reworked glacial and alluvial deposits.

CALTHORPE ISLANDS

Visited first by Parry in 1822, the islands were named by him after Lord Calthorpe. Parry states that the islands were four in number, but probably grounded ice joined the two smaller islets of the western chain, as there are actually five islands. The western islets Parry described as being composed of gneiss; they are undoubtedly an extension of the Precambrian part of Jens Munk Island leading south from Cape Elwyn. Two of these

islands are less than a mile in length and the larger of the three at the entrance to Skeoch Bay is a little over 2 miles long and less than a quarter of a mile in width.

The eastern islands in the Calthorpe group lie about 3 miles to the southeast of the westerly islets. These two, of which one was given the name of Tangle Island by Parry, are composed of limestone and so conform to the geological break along Skeoch Bay on Jens Munk Island. Tangle Island is about 4 miles in length from north to south and nearly 3 miles across. The island is low and has much shoal water surrounding it. Strand lines parallel the coast in a well-developed series, rising to a small plateau surface in the centre of the island from which drainage of the small lakes located there has breached the old beaches and limestone formations. The plateau is presumably composed of reworked glacial material overlying gently sloping limestones and shales.

The long thin island a mile north of Tangle Island stretches about 3 miles in a northerly direction and is only 1,200 feet across at its widest point. A steep scarp, 55 to 60 feet in height, forms the west coast, where the cliffs reveal limestones and shales interbedded with mud-stones that weather to soft clay. The strata dip gently to the east, where a series of five or more abandoned beaches, covered by the usual vegetation of dryas, reindeer moss, arctic poppy, and saxifrage, form the low eastern coast. The island is probably the result of a low cuesta ridge extending southwards from Jens Munk Island and forming on that island the eastern shore of Skeoch Bay. Along the west coast of the long island, weathering along horizontal fractures and vertical joints has produced rectangular fragments and blocks, creating piles of scree on the beach (Figure 11). Some of the scree has been removed by ice and wave action and nearly vertical cliffs have been formed in places. Above the limestone is a layer of reworked glacial material in the form of an upper raised beach, bringing the maximum height of the island to almost 80 feet. Numerous large granitic boulders from the strand gravel have fallen to the beach along the west coast.

Tern Island, which lies 12 miles west of Cape Elwyn, is not included in the Calthorpe Islands group. It is formed of limestone sediments and is extremely low, with offshore shallows. It is described by Parry as being about three-quarters of a mile in length and nowhere exceeding 25 feet above the sea[1]. A shallow lagoon runs into the centre of the island. Glacial deposits on the island include numerous boulders of igneous origin. Much of the interior of the island supports vegetation common to the area.

Early on September 15, the *Nauja* left the Calthorpe Islands and proceeded to the settlement at Igloolik. The Hudson's Bay Company Canso aircraft, which had been freighting supplies from Repulse Bay, flew out mail and botanical specimens for the expedition later in the day and the pilot radioed back a report on ice conditions in Frozen Strait. Apart from some loose pack off Winter Island, Frozen Strait and the coast of Melville Peninsula were free of ice.

[1] Parry, W. E.: op. cit., p. 283.

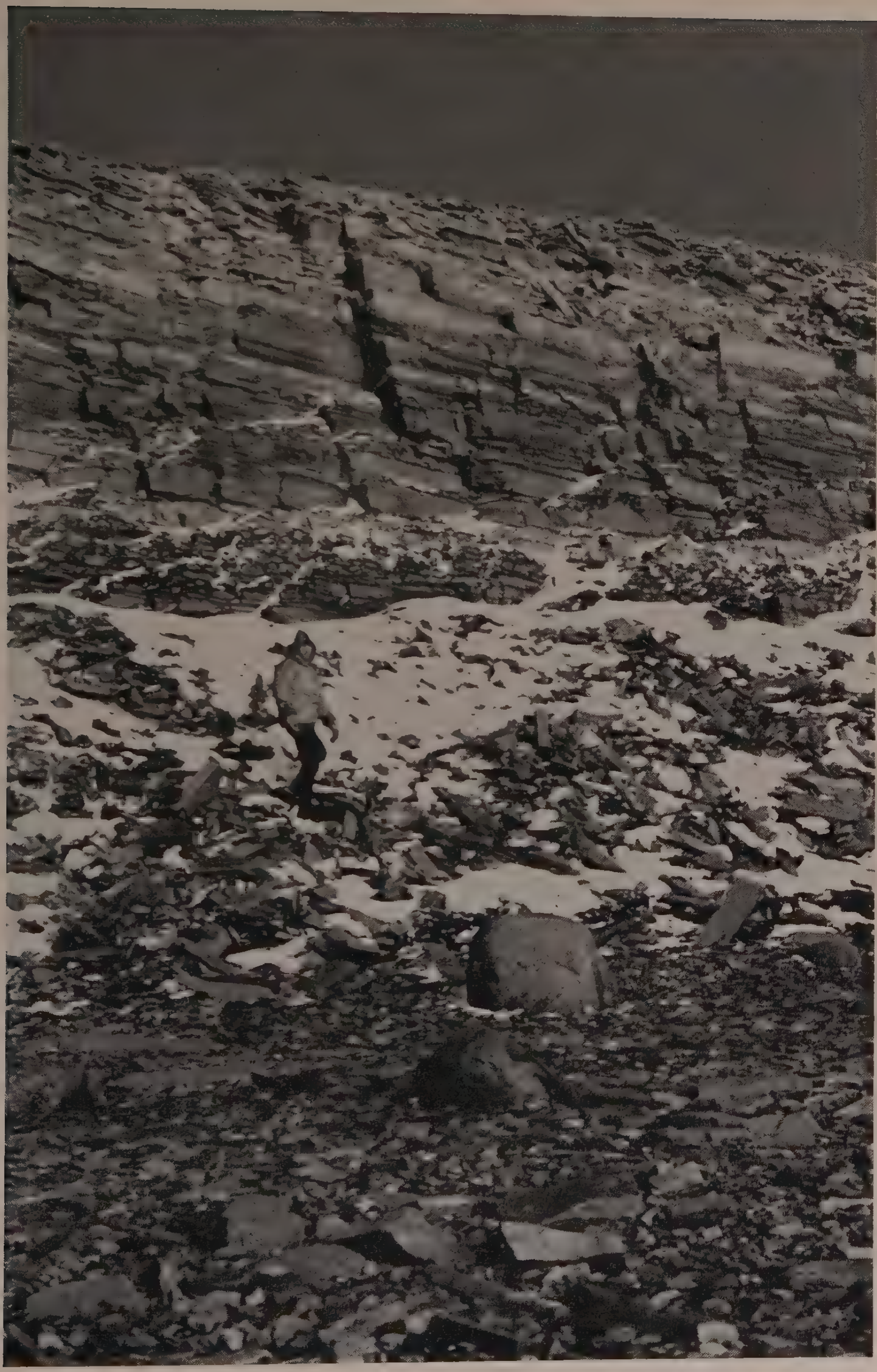


Figure 11. Scarp of Palæozoic sediments on the west side of the long island in the Calthorpe group.

Two to three inches of snow covered the ground at Igloolik and ice had formed in the smaller lakes. The following day the party left Igloolik and anchored for the night in a good harbour near Cape Jermain. Tidal readings were taken at this location and the range was found to be surprisingly small. Some members of the party visited Jenness River and examined several old Eskimo stone houses that they discovered. During the evening of September 17, they were successful in obtaining a good astronomic fix and the following morning anchor was weighed and the *Nauja* proceeded down the coast to Barrow River, where an excellent harbour was found.

A reasonably sound fix was obtained at Barrow River before the sky clouded over, and after visiting the falls on the river, this shelter was left behind early on September 19. The *Nauja* entered a small bay north of Cape Fisher, but as the anchorage appeared too small if the wind continued to rise, the expedition continued to Cape Martineau, where they anchored among the islands just as it was becoming too dark to see the scattered ice that was grounded on shoals or floating in the channels and bays.

Here a cloudy night prevented good observations. By 1000 hours the following morning, the *Nauja* had passed through Hurd Channel and anchored in the harbour at White Island. The water there was deep, and only the light anchor was dropped as it was intended that the *Nauja* would continue to the post at Repulse Bay while two of the party remained at White Island to attempt to establish a position.

A rough trip was made to Repulse Bay post due to a fresh headwind blowing against a strong tide. Four drums of oil were taken aboard at the post and a short trip made to examine some Eskimo ruins nearby. Soundings were taken in the harbour and the *Nauja* anchored for the night in a good shelter in the centre of the Harbour Islands.

An early departure from Repulse Bay on September 22 resulted in the *Nauja* passing Cape Munn on Southampton Island in the early afternoon after picking up the shore party at White Island. The west coast of Southampton Island was followed to Battery Brook, where a stop was made and a fix obtained. The next day the *Nauja* entered Wager Bay, where the entrance was sounded and an anchorage made for the night in Douglas Harbour. Tidal readings were taken here, the heights of the surrounding hills measured, and soundings were taken in Douglas Harbour. An Eskimo family was visited about a mile up the river entering the harbour and some fish were purchased from them.

The *Nauja* left Wager Bay on September 25 and travelled down the mainland coast, anchoring for the night in a small unnamed shelter, where tidal readings were taken. Poor weather delayed travel for several days en route to Churchill, which was reached on October 5 after visiting Cape Fullerton, Chesterfield, Marble Island, and Mistake Bay. Several days were spent packing and preparing the launch for storage, and the last of the party left Churchill on October 10.

APPENDIX

C.G.M.V. NAUJA AND EQUIPMENT

The *Nauja* is a 45-foot Peterhead-type boat with a 12½-foot beam and gross tonnage of 18 tons. Built at Upper LaHave, Nova Scotia, the keel and planking were of oak and yellow birch and the deck of pine. The vessel was sheathed with galvanized iron from bow to beam and was rigged for a mainsail and spanker. The spanker was removed during the voyage and the sail used as a jib.

The *Nauja* was powered by an 85-h.p. General Motors Diesel driving a 26 x 20 propeller through a 2: 1 hydraulic reverse and reduction gear. On a straight run, the vessel averaged 2·9 miles per gallon and at 1,450 r.p.m., the normal cruising speed, the *Nauja* travelled at 7 to 8 knots.

Electricity was developed by a 900-watt, 32-volt generator driven by the engine and stored by extra heavy duty batteries. The large capacity of these batteries permitted sustained use of the lights and other electrical equipment. For use in harbour and in emergency, a Grey gasoline-electric charging unit was carried.

Sleeping accommodation was provided by four bunks in the engine room, two bunks in the hold, and a folding canvas berth in the forecastle. Cooking was done on a No. 12 Atlantic Fisherman stove fitted with an oil burner.

A Marconi Marine transreceiver, Model CNL5T, 32 volt, of 22-watt output was installed in the *Nauja* and satisfactory contact was made throughout the trip with government stations and trading posts. It was found that the most effective range of the set was up to 500 miles. The Hudson's Bay Company frequency of 4356 kc/s was used in this set. A Marconi P.F.1 Forestry transreceiver, of 2·5-watt output, was carried for use by the shore parties to make contact with the *Nauja*. A small National battery receiver was also carried for use in geodetic operations to obtain time signals.

A Bendix Supersonic Depth Recorder, Model D.R.—7, was installed in the *Nauja*. This instrument, designed to read depths down to 100 fathoms, was extremely useful many times in navigating shallow and uncharted waters. Soundings were taken during almost all the running time during the voyage.

Figure 12. C.G.L. *Nauja* at Moosonee.

RÉSUMÉ

La découverte relativement récente de trois îles dans la partie est du bassin Foxe a attiré l'attention du public, au Canada, vers ce coin de notre pays qui n'apparaissait pas encore sur la carte.

Le gouvernement fédéral décida d'envoyer une expédition de géographes en 1949, afin d'explorer ces îles, d'y établir des points géodésiques, d'en reconnaître les côtes et d'y recueillir le plus de renseignements possible. L'expédition, dirigée par des géographes du Service de géographie, Ministère des Mines et Ressources, comprenait aussi des géologues, des géodésistes et des biologistes, et voyagea à bord du *C.G.S. Nauja*, pendant l'été de 1949. (Les caractéristiques de ce petit navire sont décrites dans l'appendice de l'article).

Cet article est le premier qui soit publié de cette expédition. Il débute par une brève introduction historique, énumérant les explorateurs qui ont participé à la découverte de ce territoire de l'Arctique oriental canadien: Parry (1821-23), Hall (1868), Spicer (1897), Hantzsch (1910), MacMillan (1921), Danish Fifth Thule Expedition (1922-24), Bray et Rowley (1936) et Manning (1938-40). On raconte ensuite le voyage du *Nauja*, escale après escale, résumant les renseignements que l'on y a recueillis sur la géographie physique des îles du Bassin.

Le *Nauja* quitta Moosonee, port de la baie James, au début de juillet 1949 et se dirigea lentement vers le nord. On visita en route les postes et autres établissements de la baie James et de la baie d'Hudson. Le 14 août le navire arrivait en vue de l'île du Prince-Charles.

L'île du Prince-Charles est la plus grande des "nouvelles" îles du bassin Foxe. Très basse et sans relief accidenté, l'île est recouverte en certains endroits de dépôts glaciaires. On a découvert de nombreux lacs sur l'île et plusieurs petites rivières; mais le système de drainage est très lâche, n'ayant pas encore atteint sa forme définitive. On y a vu plusieurs caribous ainsi qu'un ours polaire et l'on a identifié plusieurs espèces d'oiseaux.

L'île Air Force, située à l'est de l'île du Prince-Charles, est beaucoup plus petite et possède les mêmes caractéristiques. Une arête de gneiss granitique, cependant, change un peu l'aspect topographique. Cette arête s'élève au centre de l'île à quelque 250 pieds et fait saillie au milieu de dépôts marins et glaciaires. On a identifié plusieurs espèces de mammifères et d'oiseaux.

En quittant l'île Air Force, les membres de l'expédition se divisèrent en deux groupes: l'un visita l'île Foley, la dernière des trois "nouvelles" îles, et l'autre la péninsule Baird. L'île Foley est formée d'un plateau de calcaire ordovicien et de gneiss précambrien; la surface est couverte en certains endroits de dépôts marins et glaciaires.

Les îles Tweedsmuir furent reconnues ainsi que la petite île Anderson. Le 5 septembre, le *Nauja* se dirigea vers les îles Spicer situées à environ 45

milles à l'ouest de l'île du Prince-Charles. A partir de ce moment-là, il s'agissait de recueillir des renseignements additionnels sur la topographie, le relief, la géologie, la flore et la faune des autres îles du bassin qui avaient été découvertes auparavant mais dont on connaissait peu de choses. Ainsi les membres de l'expédition visitèrent ou observèrent à distance les îles Rowley, Bray, Koch, Jens Munk et Calthorpe.

Le 15 septembre, le *Nauja* entreprit son voyage de retour en côtoyant l'est de la péninsule Melville, l'ouest de l'île Southampton et, finalement, la partie ouest de la baie d'Hudson. Le navire s'arrêta à plusieurs postes le long du rivage et atteignit le port de Churchill le 5 octobre 1949.

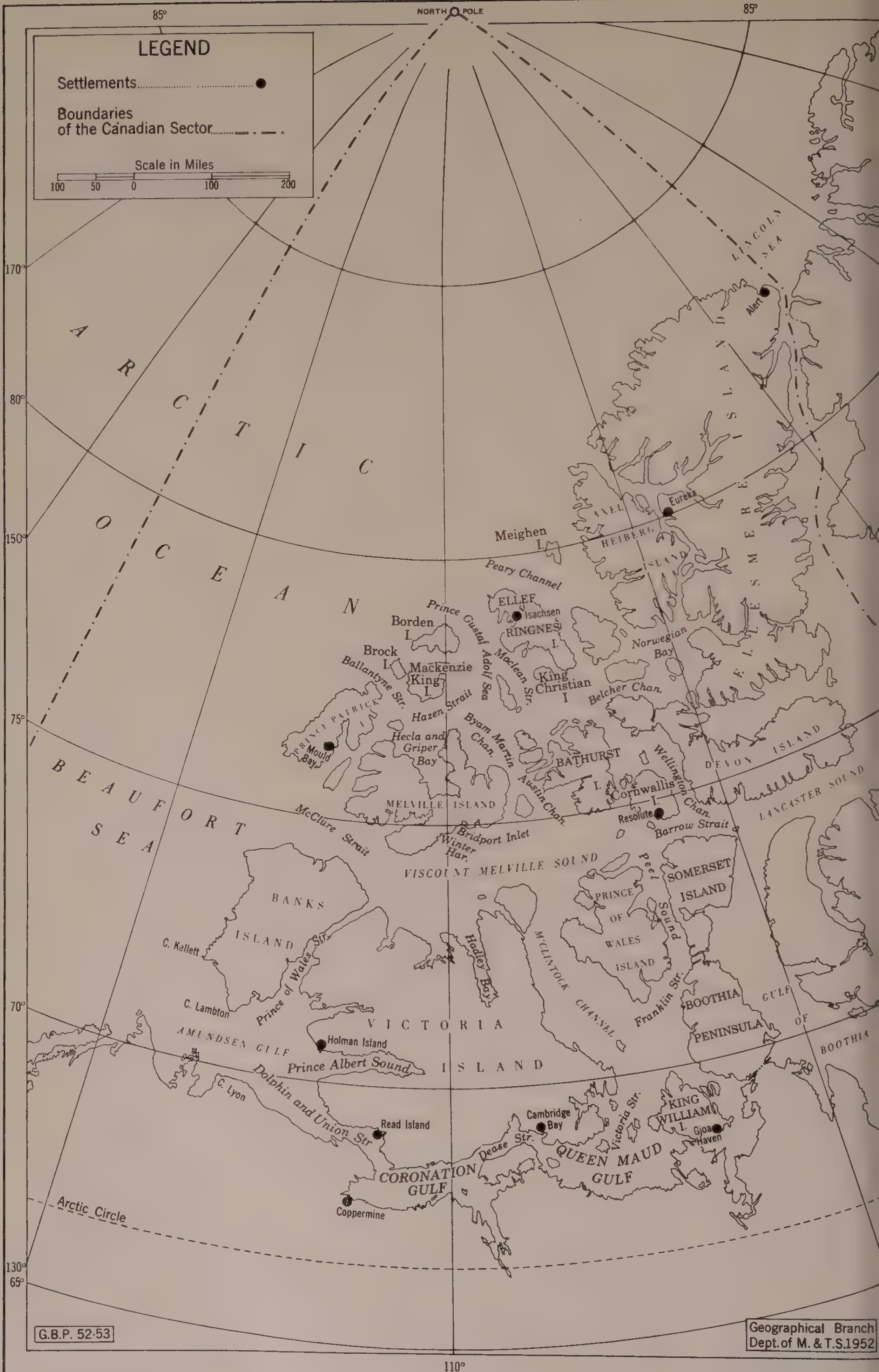


Figure 1. Location map.

THE PHYSICAL GEOGRAPHY OF THE WATERS OF THE WESTERN CANADIAN ARCTIC

John L. Jenness[1]

The Canadian Arctic Archipelago consists of many large and small islands, separated by straits of varying widths. The broad east-west waterway—the direct Northwest Passage route—through the heart of the archipelago creates a division into a northern and a southern half, and there are also several rather less distinct divisions resulting from the more or less parallel arrangement of the north-south channels. Whatever the arrangements of land and sea, however, their origin is not yet clearly understood. It may be, as Taylor[2] has suggested, that the polar islands were once parts of continental North America but became separated from it as a result of a tendency on the part of the continent to drift to the southwest, thrusting up the Cordillera on its way and leaving behind blocks of the crust at various distances. Or, more plausibly, the major separation of the Arctic islands from each other and from North America may have been due to settling down of slices of the earth's crust like rift valleys, the sinking going so far as to allow the sea to enter[3]. According to Coleman, the further subdivision has been brought about by the drowning of river valleys that had already become deeply cut out at a time when the land stood higher relative to sea-level than it does at present.

THE NATURE OF THE CONTINENTAL PLATFORM

The whole Canadian archipelago forms a broad poleward extension of the continental platform that borders the north side of the North American continent. The Arctic islands and the intervening straits and channels form the emerged and submerged parts of this platform.

The western edge of the continental platform does not seem to lie far to the west of Banks and Prince Patrick Islands. During Stefansson's ice travel in 1914 from the north coast of Alaska to Burnett Bay near the northwestern end of Banks Island, for example, he came to the edge of the continental platform at a distance of about 50 miles from the Alaska coast[4] and only returned to it when within 100 miles of Banks Island[5]. On a later occasion, when travelling out on the Arctic Ocean in a northwesterly direction from Banks Island, he recorded a series of soundings that drop off from a variable depth of 100 to 200 fathoms close to the land to depths exceeding 750 fathoms in about 130 degrees west longitude,

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[1] John L. Jenness, B.A., Cambridge, Ph.D., Clark, Associate Professor of Geography, University of Pittsburgh. This paper is based on the writer's doctoral dissertation and the field investigations he carried out for the Geographical Branch during the summer and winter of 1948 and the summer of 1949 while a member of its staff.

[2] Taylor, F. B.: Bearing of the Tertiary Mountain Belt on the Origin of the Earth's Plan; Bull. Geol. Soc. of Amer., vol. 21, pp. 179-226.

[3] Coleman, A. P.: Unsolved Geological Problems of Arctic America. In Problems of Polar Research; Amer. Geog. Soc., New York, 1928, p. 71.

[4] Stefansson, V.: The Friendly Arctic; Macmillan Co., New York, 1922, p. 157.

[5] Ibid., pp. 216-225; *See also* map facing p. 140.

approximately due west of the southern end of Prince Patrick Island[1]. Describing his travel near his farthest point of advance into this part of the Arctic Ocean, Stefansson says:

"we left the area of shallow soundings and were now travelling over an ocean of unknown depth, for our sounding wire of 4,500 feet never sufficed to reach bottom"[2].

Elsewhere, however, the edge of the platform apparently lies relatively much farther from the islands. Stefansson has described the configuration of the bottom north of Borden Island as follows:

"At the shore floe, fifteen or twenty miles from land we got a sounding of four hundred and sixty-eight meters (251 fathoms)...... When we were eighteen miles farther from land we got four hundred and fifty-two meters; ten miles farther on four hundred and forty-four meters. The bottom we were travelling over was therefore similar to that of an enclosed sea as we knew from theory and found later when we ran a line of soundings across Melville Sound between Melville and Victoria Islands. As we advanced on the ice the soundings became deeper and deeper until about a hundred miles from land we had five hundred and twenty-two meters. Then they began to shallow very gradually until forty miles farther on we had four hundred and ninety-six...."[3].

Aerial flights have failed to reveal any land in this direction, however, so that the only assumption that can be made is that the platform terminates at some unknown distance beyond Stefansson's Farthest.

The channels and straits between the many islands in the western part of the archipelago all seem to have a similar or even shallower depth. McMillan[4] notes 225 fathoms off Cape Providence as the deepest sounding recorded in Viscount Melville Sound by the "Arctic" expedition, 1908-09. Stefansson obtained no soundings greater than 502 metres (274 fathoms) in his crossing between Melville Island and Banks Island in 1917[5]. Between Banks Island and the continent, the depth would appear to be mostly under 100 fathoms. Prince of Wales Strait is considerably shallower; the charted depths range from 18 to 62 fathoms except in the vicinity of Princess Royal Islands where there is a charted depth of 8 fathoms in mid-channel[6]. Stefansson recorded a sounding of 69 fathoms in Ballantyne Strait midway between Prince Patrick and Brock Islands[7], and others of 100 fathoms south of Mackenzie King Island[8]. He noted a maximum depth of 315 metres (160 fathoms) in Maclean Strait between King Christian Island and the Findlay group[9], a maximum of 450 metres (246 fathoms) in the Prince Gustav Adolph Sea between Borden Island and Cape Isachsen at the northern end of Ellef Ringnes Island[10], and a maximum of about 400 metres (219 fathoms) in Peary Channel, which separates this latter island from Meighen Island[11]. Barrow Strait is mostly under 100 fathoms in depth, as are also Austin and Byam Channels. The remaining north-south channels

[1] Ibid., pp. 296, 298, 299; *See also* map facing p. 292.
[2] Ibid., p. 298.
[3] Ibid., pp. 610, 612.
[4] McMillan, J. O.: Cruise of the Arctic, 1908-09; Govt. Printing Office, Ottawa, 1910, pp. 469-470.
[5] Stefansson: op. cit., p. 633.
[6] Sailing Directions for Northern Canada; United States Navy, Hydrographic Office, Washington, 1946, p. 518.
[7] Stefansson: op. cit., p. 329.
[8] Ibid., p. 341.
[9] Ibid., p. 359.
[10] Ibid., p. 503.
[11] Ibid., p. 517.

among the Parry and Sverdrup Islands are apparently of the same shallow nature. All the channels between the continental mainland and the part of the archipelago lying west of Boothia Peninsula are also relatively shallow. South of King William Island in Simpson Strait occurs what is probably one of the shallowest parts of the entire archipelago. Amundsen[1] and others have shown that the depth of water here is rarely much greater than 10 fathoms, and that it generally is considerably less. Soundings made by the *St. Roch* in 1941 showed depths in the western end of the Strait of 6, 7, and 8 fathoms with several 3-fathom patches[2].

No soundings appear to have been made in the comparatively broad M'Clintock Channel, which lies between the east coast of Victoria Island and Prince of Wales Island. It is not unreasonable to suppose, however, that this channel is no deeper than the deepest of the other inland waterways in the western part of the archipelago.

It should be noted that, even excluding Baffin Bay, soundings in the eastern sector of the archipelago indicate the existence of certain places where the water is deeper than that recorded in any part of the western sector. For example, at a spot in Belcher Channel, approximately 5 miles north of the entrance into Cardigan Strait, no bottom was obtained at 400 fathoms. Eureka Sound, also, is apparently a deep strait despite its limited width. It is highly probable, however, that peculiar local conditions (such as major fault lines) prevail in such localities and that further investigation will produce a reasonable explanation concerning the origin of these and of any other unexpectedly deep places.

Far more soundings are of course necessary before anything very precise is known about the nature of the submerged parts of the continental platform north of the North American continent. The limited amount of data available tends to support Nordenskiöld's hypothesis[3] that the sea within the polar regions is relatively deeper above the continental platform than in most other parts of the globe. He notes that:

"......the shallow continental shelf which surrounds so much of the land of the globe at a depth of about two hundred meters....at least around the Antarctic continent lies about two hundred to three hundred meters deeper than usual".

Many of the soundings taken on the platform within the Canadian Arctic Archipelago exceed the 200-metre norm, but within at least the western part of the archipelago, the recorded depths are nowhere greater than 522 metres, the maximum recorded by Stefansson north of Borden Island. It thus seems probable that the land is still depressed by as much as 300 metres beyond the normal.

Washburn[4] has shown that within the archipelago a rapid and essentially continuous rise of the land relative to sea-level has been taking place in geologically recent times, and he has produced evidence from

[1] Amundsen, R.: The Northwest Passage, Vol. II; E. P. Dutton Co., New York, 1908, pp. 107, 116.
[2] Sailing Directions for Northern Canada, p. 534.
[3] Nordenskiöld, O., and Mecking, L.: The Geography of the Polar Regions; Amer. Geog. Soc., New York, 1928, p. 57.
[4] Washburn, A. L.: Reconnaissance Geology of portions of Victoria Island and Adjacent Regions; Geol. Soc. of Amer., New York, 1947, pp. 69-73.

Cambridge Bay that indicates that the land is probably still rising. Evidence of emergence is widespread over the whole archipelago. If it is assumed that the land became depressed, perhaps as a result of the Pleistocene glaciation of North America, and that the subsequent emergence indicates a tendency to return to a position of equilibrium, it then offers a possible explanation (if equilibrium has not yet been attained) for the apparent fact that the continental platform lies deeper in these regions than elsewhere over the greater part of the globe.

Considerable differences exist in the sizes and shapes of the various water bodies that encompass the islands of the western part of the archipelago. Some of the larger of these, such as Viscount Melville Sound, are almost large enough to be classed as enclosed seas. Some of the smallest, on the other hand, are merely narrow gaps separating adjacent land masses. Many of the latter show typical drowned landscape characteristics, and may be considered submerged parts of the lands they now separate. Simpson Strait, which now separates King William Island from the continental mainland, is a typical case. Some straits such as Bellot Strait between Somerset Island and Boothia Peninsula occupy ancient fault lines. Others, among the Parry Islands, owe their origin mainly to the distortion of the structure into a series of anticlines and synclines. In others, differential erosion characteristics are present; and some apparently owe their origins to a combination of all these factors.

Among the major embayments, some bear an unmistakable relationship to past glaciation. This is especially true around Victoria, King William, and Prince of Wales Islands, but is less probable elsewhere. As in the case of the straits, however, the characteristics of many of the important bays can be attributed most readily to folding or faulting of the structures, drowning of the lower courses of river valleys, differential erosion, or a combination of these factors.

TIDES

As has been noted, the waterways of the western sector of the achipelago present a pattern of considerable complexity, and one would expect to find this complexity expressed visibly by the tides and currents. Though this is in fact true, tidal phenomena nevertheless retain a broad uniformity in both range and character, and the main currents associated with these tides can also be recognized despite the tendency of local currents to obscure them.

A principal feature of the tides in the Western Arctic is their consistently small range. The maximum range, even at spring tide, is probably nowhere as great as 10 feet; at most places it is less than 5, which contrasts markedly with certain parts of the Eastern Arctic. The lowest ranges in the Western Arctic coincide with neap tides and may be less than 1 foot.

Tidal readings have been made at a variety of widely scattered points in the Western Arctic. Although many of these readings are of only one- or two-cycle duration, made without respect to the phase of the sun or moon, they nevertheless give some indication of the smallness of the range between low and high tide as a whole.

At Cambridge Bay, Victoria Island, Collinson[1] recorded a minimum range of 7 inches and a maximum of only 28 inches. Also at Cambridge Bay, Burwash[2] recorded a maximum tidal range of 25 inches, but noted that wind could increase the apparent range from 25 to 34 inches, or could decrease it to 11 inches, depending on the direction from which the wind blew.

Captain R. J. Summers of the Hudson's Bay Company is reported as saying that the normal tide at Walker Bay on the west coast of Victoria Island is about 18 inches[3], but he confirms the observations of others that a west wind will raise the water considerably more whereas an east wind will lower it. A range of 2 feet was noted by the author in Prince Albert Sound and of just under 2 feet at the head of Minto Inlet. Storm beaches at this latter place show that even at highest water the range probably does not exceed 4 feet.

McClure[4] mentions that in Prince of Wales Strait the water rises about 3 feet at spring tide and little, if any, at neap tide. Storkerson[5] found a range of only a few inches between high and low tide at Armstrong Point, in the vicinity of the Princess Royal Islands, which was confirmed by the author's observations midway between this point and the outlet of Prince of Wales Strait into Viscount Melville Sound. Richard Collinson Inlet on the north coast of Victoria Island would seem to have an average range of about 3 feet.

Comparable readings have been made at Banks Island and in other parts of the Western Arctic. In DeSalis Bay, Banks Island, the maximum range seems to be less than 5 feet. At Cape Kellett the spring tides are said to be only one-half foot[6], although Stefansson[7] notes that wind-generated storm tides on this west coast are capable of raising the level of the water 6 or 8 feet above ordinary high tide, whereas strong offshore winds produce the reverse effect. The tide in Castel Bay, northern Banks Island, was estimated by the author to average between $2\frac{1}{2}$ and 3 feet, a figure that compares fairly closely with 2-foot tides noted in nearby Mercy Bay by members of the McClure expedition. At King William Island, Burwash observed a maximum difference between high and low water of 32 inches. The Bernier expedition kept a detailed record of the

[1] Collinson, R.: Journal of H.M.S. "Enterprise", 1850-51; Sampson, Low, Marston, Searle and Livington, London, 1889, p. 291.

[2] Burwash, L. T.: Report of exploration and investigation along Canada's Arctic Coast Line from the delta of the Mackenzie River to Hudson Bay, 1925-1926; Dept. of the Interior, Ottawa, 1927, Appendix.

[3] Washburn: op. cit., p. 77.

[4] Osburn, S.: The Discovery of the Northwest Passage by H.M.S. Investigator, 1850-54; Longmans, Green, Longmans and Roberts, London, 1857, p. 200.

[5] Stefansson: op. cit., p. 408.

[6] Sailing Directions for Northern Canada, p. 484.

[7] Stefansson: op. cit., p. 223.

tidal range in Winter Harbour, Melville Island, throughout the period November 1908 to March 1909 and obtained the following results: maximum range 4·9 feet, minimum range 0·64 foot. The average height of the spring tides was about 3·6 feet and that of the neap tides about 1·3 feet[1]. In Hecla and Griper Bay, on the north side of Melville Island, the tide is said to rise about 30 inches[2]. At the head of Liddon Gulf, on the west side of the same island, a range of 4 feet 8 inches was recorded by the author. Three observations on Bathurst Island indicate a small range. At Cape Hotspur, on the west coast, the tide is not over a foot in height, but a tide of 5 feet has been observed in May Inlet at the north end of the island[3], and in Pell Inlet, northwestern Bathurst Island, the author recorded a tide of approximately 4 feet.

In addition to the above observations, preliminary reports from the weather stations in the far north indicate that the maximum tidal range at Resolute Bay, Cornwallis Island, is approximately 6 feet, and that at Isachsen, on the west coast of Ellef Ringnes Island, the range is only about half as large[4]. At Mould Bay, Prince Patrick Island, the range is said to be between 12 and 20 inches.

Throughout the Western Arctic the tides go through approximately two complete cycles during the course of a single 24-hour period. The interval of time between successive high tides is approximately 12 hours, as is also that between successive lows. These intervals would seem to remain more or less constant near the western limit of the archipelago, but apparently become somewhat irregular as they approach its centre because of the overlapping of both eastern and western tidal undulations. Thus, Rae has noted an inconsistency in the intervals between the successive high and low tides at Resolute Bay, Cornwallis Island, whereas Bernier makes no mention of any inconsistency at Winter Harbour, Melville Island. That the time interval between successive tides should become less constant towards the east, is, however, not altogether surprising. Throughout at least the greater part of the archipelago the tides have their primary origin in the Arctic Ocean to the west; the Atlantic Ocean tides have little effect westward of Davis Strait and Baffin Bay, as is shown by the comparatively high range along the east coasts of Baffin and Bylot Islands, and the abrupt decrease to a slight range westward from there. Nevertheless, we must expect the Baffin Bay tides to have some modifying effects upon regimes in the nearby straits and channels, even though their influence upon the range is not great.

More conspicuous than the variation in the time intervals between successive high phases and low phases of the tide, is the diurnal inequality[5] in the heights of the tides. A distinct inequality has been recorded in

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[1] Bernier, Capt. J. E.: Report on the Dominion of Canada Government Expedition to the Arctic Islands and Hudson Strait on board the D.G.S. *Arctic;* Government Printing Bureau, Ottawa, 1910, p. 340.

[2] Ibid., p. 470.

[3] Ibid., p. 415.

[4] Rae, R. W.: Tidal Observations at Resolute Bay and Isachsen; Arctic, vol. 3, p. 103.

[5] When the two high waters of the day do not rise to the same height above sea-level, and the two low waters do not fall the same distance below sea-level, this variation in height is known as "diurnal inequality". (Marmer, H. S.: The Tide; D. Appelton and Co., New York, 1926, p. 47.)

widely scattered localities. For example, Rae notes a considerable diurnal inequality at Resolute Bay. Bernier's records show that at Winter Harbour, Melville Island, the inequality amounts to about 25 per cent of the range. A similar variation was observed by the author at the head of Liddon Gulf, Melville Island, and at both Pasley Bay and Bathurst Inlet on the mainland coast of the continent. At Bathurst Inlet the inequality is apparently confined to the flood phase of the tide; it is either totally absent or insignificant during the periods of ebb. The range here is in any case very slight—about 1 foot—but as a result of this inequality, the tide rises approximately 12 inches between the time of one ebb and the subsequent flood, whereas following the second ebb no visible rise in water level takes place and this "rising tide" is recognizable only by a slight inward movement of the current.

At the head of Liddon Gulf, on the other hand, inequality appears to exist in both the flood and ebb phases of the tide. Here, on August 10, 1948, the author set out a tide pole just prior to the turn of the ebb tide. The watermark left by the previous flood still remained as a quite distinct line upon the strand. The first rising tide failed to rise as high as this watermark, a range of 3 feet being recorded between the lowest point of the preceding ebb and peak of the flood at this time. The following ebb tide, however, lowered the water level considerably below its position of 12 hours previous, causing a broad tidal flat to be exposed as part of the beach. The following high tide reached the watermark that had been left by the last flood tide prior to our arrival, thus giving a range of 4 feet 6 inches as compared with the 3 feet recorded earlier. No diurnal variation could be distinguished in the time it took the flood and ebb phases to reach their respective peaks; if this brief observation is at all representative, then a distinct variation exists in the range of each successive tide and this variation is brought about by differences in the amount of rise and fall of both the flood and ebb phases respectively. That this is probably the case is suggested by the fact that the wind blew fairly steadily from the east throughout the entire period, and its effect, if any, would have been merely to lower the total range, but would in no way have contributed to the observed inequality.

In addition to the above, it was further observed by the movements of ice in the inlet that a pronounced incoming current accompanied the lesser of the two rising tides and an outgoing current of a somewhat reduced velocity occurred during the subsequent ebb phase. Little or no current was felt during the second flood phase, and in fact throughout this complete 12-hour ebb-to-ebb cycle the ice continued to mill about as though only the wind was disturbing it.

Whether or not this diurnal inequality in the tidal range is characteristic of the western part of the archipelago as a whole, is not yet know with certainty. That it probably is, however, is suggested by the fact that it has been recorded from a number of widely scattered localities. The extraordinary configuration of land and sea bodies obviously has a

considerable bearing on the subject, for one set of local conditions will accentuate any tendency towards inequality in successive tides, whereas another set will disguise it. No evidence was obtained by the author of diurnal inequality in the tides at Castel Bay, northern Banks Island, Richard Collinson Inlet, northern Victoria Island, and Pell Inlet in northwestern Bathurst Island. However, although this lack of evidence does not prove the absence of an inequality in these places, it does tend to indicate that any inequality that may occur is considerably less marked than at numerous other points in the Western Arctic.

CURRENTS

Mecking[1] has pointed out that "in the American Archipelago. . . . the main currents in the straits are often obscured by local tide currents". This is especially true in some of the narrow straits and channels, particularly in those that are studded with small islands. Even in the largest bodies of water, however, the ebb and flood of the tide give rise to alternating current directions. Thus, the early explorers have more than once reported the current as flowing in one direction when actually the main outflow was in the opposite direction. For example, in 1819, when Parry reached the eastern entrance of McClure Strait, in the vicinity of Cape Hay, he recorded that the current was setting to the westward at a rate of 2 miles an hour against a fesh gale from that quarter. This observation might quite easily leave the impression that the current carried water from the heart of the archipelago westwards into the Arctic Ocean. In actual fact the contrary is the case, as Bernier discovered during his prolonged stay on Melville Island nearly 100 years later. Conducting his observations at almost the same locality as Parry, he came to the conclusion that the flood tide runs westward and the ebb tide eastward, and the general outflow is eastward, carrying many large fields of ice in the autumn[2].

Though very little is known about the currents of the Western Arctic, the main direction of drift has been established, and something is known also about movements of currents in many of the lesser channels. Even without knowing the main direction of outflow of all these channels, it is possible to come to some conclusions concerning the general circulation of the waters as a whole.

West of Banks Island there appears to be a permanent drift that moves southwards along the coast and then swings westwards to pass along the coast of Alaska. During certain seasons this current continues across to the Siberian part of the Arctic Ocean as is shown by the drift of the *Karluk*, which was carried 1,000 miles in 4 months from Camden Bay, Alaska, to Wrangell Island[3]. However, Stefansson believes that a great eddy may exist in the Beaufort Sea. He bases this belief on his

[1] Nordenskiöld and Mecking: op. cit., pp. 129-130.
[2] Bernier: op. cit., p. 38.
[3] Bartlett, R. A., and Hale, R. F.: The Last Voyage of the "Karluk"; Small, Maynard and Co., Boston, 1916.

own observations that 300 miles north of Alaska the current is east, and that it bends south as it reaches the coast of Prince Patrick Island, and then swings west again as it nears the mainland coast of the continent[1]. The situation to the north and northeast of this Beaufort Sea "eddy" is not clear, however. It is known that the polar pack-ice presses most heavily against the northwest-facing sides of all the outermost islands of the archipelago from Brock Island eastwards, but whether this is partly due to an eastward-moving current, or if it is wholly due to strong northwesterly winds remains undetermined. Stefansson speaks of the ice north of Borden Island as being "under restraint as great as the stresses were heavy"[2], which might indicate that the current direction opposes that of the prevailing winds (i.e., that the current moves in a westerly direction).

One other major known current crosses the archipelago through McClure Strait, Viscount Melville Sound, Barrow Strait, and Lancaster Sound. As noted already, this is a general drift towards the east resulting from the fact that tide currents having an easterly component are somewhat stronger than those with a westerly component. Because of this easterly drift, waters within the archipelago gradually work their way towards Baffin Bay, where they have their outlet. Because of it, also, some of the waters that pass down the west coast of Prince Patrick Island are drawn into the archipelago through McClure Strait.

McClure Strait is not the only place where waters branch off the permanent current in the Beaufort Sea and swing in among the islands. A similar movement takes place south of Banks Island. The current appears to form an eddy that moves in a clockwise direction around Amundsen Gulf, but part of it penetrates into the nearby straits and bays in the form of tidal currents. Feelers from it move northwards through the centre of Prince of Wales Strait during the period of flood tide, but as soon as the tide ebbs the current reverses its direction and comes out of the strait again. Here, the current moving south on the ebb tide tends to be stronger than that moving north on the flood. It is thus quite possible that a part of the water that enters the archipelago north of Banks Island through McClure Strait is diverted into Prince of Wales Strait and finds its way out again farther south. Other feelers from the "eddy" in Amundsen Gulf enter Minto Inlet and Prince Albert Sound on Victoria Island. Whether the flood or the ebb current has the stronger component is not known, but the author has seen both embayments cleared of ice in a matter of only a few hours, even though they had previously been entirely filled with it; once clear, they tend to remain ice-free during the rest of the summer season. Yet another feeler from the "eddy" reaches Coronation Gulf through Dolphin and Union Strait. This, too, is an alternating (tidal) current. In the narrows of Dolphin and Union Strait, both phases are very strong, though the main direction of flow appears to be eastwards. Much of the force of this current becomes spent once it enters the wider and deeper Coronation Gulf, for it becomes decreasingly evident towards the east.

[1] Stefansson: op. cit., p. 185.
[2] Ibid., p. 613.

There are numerous channels entering McClure Strait, Viscount Melville Sound, and Barrow Strait from the north, and two others, M'Clintock Channel and Peel Sound, which join this waterway from the south. It appears that these channels have their outflow into this main stream that moves through the heart of the archipelago towards Baffin Bay. This has been substantiated in one case in which two vessels, the *Advance* and the *Rescue*, became frozen in the ice in Maury Channel north of Cornwallis Island in October 1850, from which point they drifted through Wellington Channel to Lancaster Sound at the rate of $1\frac{1}{2}$ miles a day[1]. The main outflow from Penny Strait, which lies north of Maury Channel, also seems to be southwards through Wellington Strait. Elsewhere, however, conclusive data are lacking. Even though it is now know that currents are present in at least most of the other channels that open into the main east-west waterway, and that the current appears to move northwards during one phase of the tide and in the opposite direction in the other phase, it is still not known which of these current directions is the dominant one.

Although the literature gives no data on current conditions in M'Clintock Channel, some indication of the presence or absence of currents may perhaps be obtained by observing the ice conditions during the summer months. It seems noteworthy that this channel never becomes entirely free of ice, and that even in favourable years it remains solidly covered long after Viscount Melville Sound to the north of it has started to clear. This fact suggests that any current that exists there must be slight. The considerable width of the channel, together with the knowledge that the main outflow of Viscount Melville Sound continues eastwards past its opening supports this assumption.

South of M'Clintock Channel the straits tend to be shallow and studded with many small islands. Currents run in and out among the islands, making it difficult to recognize any single main direction of movement. The movement of the sea-ice is significant here also, for even after this ice breaks up in the early summer, it continues to mill about almost until the time of freeze-up. Its ultimate disappearance comes from melting away, and not because it has been carried elsewhere by winds or by the current. The existence of much very shallow water in these straits and in Queen Maud Gulf may cause some of the ice to ground, thereby interfering with the movement of the rest; but an absence or near absence of main currents should be a factor in making the ice remain close to where it originated. As this corner of the archipelago is remote from the places of origin of main current-producing zones, it is concluded, even without positive supporting evidence, that main currents are lacking here and purely local tide currents dominate among the many islands.

The northern outlying parts embodying the northern Parry Islands and the Sverdrup Islands include an area of islands, seas, and straits that were not even known to exist prior to the end of the nineteenth century.

[1] Kane, E. K.: The United States Grinnell Expedition in Search of Sir John Franklin; Harper and Bros., New York, pp. 210-334.

Some parts were seen for the first time during the second decade of the present century, when Stefansson made his discoveries in 1915-17. Much of the region has not been revisited since it was first explored. It is, therefore, not altogether surprising that the literature of the region bears few references to tides and currents. Such references as exist are for only a few of the many straits and channels. Ice conditions can be studied on aerial photographs, and are of some assistance in making deductions; but specific data are needed before any positive conclusions can be arrived at about the distribution of the major currents, or about the main directions of outflow from this part of the archipelago.

From Stefansson's accounts it is evident that currents are present in each of the three straits bordering on the Arctic Ocean between Prince Patrick Island and Meighen Island. In at least two of these, the current direction alternates with each change in the tide, for Stefansson's descriptions of Prince Gustav Adolph Sea and Peary Channel mention this reversible character. Speaking of the Prince Gustav Adolph Sea, Stefansson[1] remarks that he had been "crossing the mouth of a strait....with strong currents to the northwest and southeast, apparently tidal currents". Later he recorded similar currents during his crossing of Peary Channel. The direction of these currents alternated between northwest and southeast[2]. The current in the third channel, Ballantyne Strait, is probably also tidal, although Stefansson merely mentions that "there was a strong current running a little west of north"[3]. It may even be that a single outflowing current exists here, in which case it would carry outflowing water from the archipelago into the permanent current that moves southwards off the coast of Prince Patrick Island.

There is not yet any positive way of knowing the main direction of current movement in any of the far northern channels adjacent to the Arctic Ocean. It is not even safe to conjecture whether these bring an inflow of water into the archipelago, or whether they carry an outflow away from it. In general, even the aerial photographs are of no help. They were taken during the summer of 1950, and although they show the ice considerably broken up in Norwegian Bay and Belcher Channel, they reveal only a uniform surface of old ice covering the large bodies of water north of Bathurst and Melville Islands.

A single exception might be made for the photographs of Sverdrup Channel. At the time these were taken (July 17, 1950), the ice between Meighen and Axel Heiberg Islands was still solid. The significant thing, however, was the character of this ice cover. It was patterned in such a way as could only have been created by the intermingling of new and old ice; thus, it showed that Sverdrup Channel had been open not more than 1 or 2 years previously. The "patterned" ice continued from the northern end of Sverdrup Channel as far south as Norwegian Bay, even though it

[1] Stefansson: op. cit., p. 503.
[2] Ibid., p. 517.
[3] Ibid., p. 329.

was totally absent from the other straits that border on the Arctic Ocean farther west. It is evident, therefore, that some force is present in Sverdrup Channel that can produce this break-up. The fact that the break-up occurred throughout the length of the channel is a reason for believing that this force is actually a continuous current moving through it.

These same air photographs show that the pattern of broken ice ends abruptly at the northern end of Sverdrup Channel as a sharp line that crosses from the north end of Meighen Island to the coast of Axel Heiberg Island. The straightness of this line appears to have remained unchanged from the time it was first formed by the opening up of a tide crack across the channel. This would not seem probable if there is a strong current present whose main direction of flow is northwards towards the Arctic Ocean. An outflow in this direction would more likely cause the loose ice to keep rubbing against the unbroken edge of the crack, thus breaking this edge in some places and causing ice ridges to pile up in others. Under such circumstances one might expect this edge to show up now as an irregular line, which is not the case. It, therefore, seems possible that the dominant or only direction of current movement through Sverdrup Channel is southwards, and that this movement represents an inflowing of water from the Arctic Ocean into the archipelago.

One locality that is known to have very strong currents lies outside the region under discussion, but affects some of the channels included within this paper. This is the narrow gap that separates Devon Island from the southwestern end of Ellesmere Island. North Kent Island lies in the middle of this gap and separates it into two channels, Cardigan Strait on its western side and Hell Gate to the east. Fast-moving currents flow through both of these channels. Some indication of the amount of movement can be gathered by the report that Hell Gate was free of ice when it was seen from the air in March and again in April 1948. The currents here are tidal; they flow with almost equal rapidity to north and south on alternate phases of the tide, but the main outflow appears to be to the south. Together with strong local winds, they contribute substantially to the break-up of the ice each year in Norwegian Bay and Belcher Channel. For reasons that are discussed below, their effects probably are felt also beyond the limits of Norwegian Bay and Belcher Channel.

The fairly sizable expanse of water lying north of Melville and Bathurst Islands is known in its various parts as Hazen Strait, Desbarats Strait, Maclean Strait, and Danish Strait. This region appears to be essentially a single enclosed sea, but it can be thought of as consisting of an eastern and a western part, which lie to the east and west respectively of the Findlay group of islands, which lie approximately at its centre. Hecla and Griper Bay, which penetrates deep into the northern side of Melville Island, is, for all practical purposes, an integral part of the western sector.

The western part of the enclosed sea seems to have the greatest degree of ice solidarity of any part of the archipelago. The eastern part, on

the other hand, is marginal both to this area and to Norwegian Bay and Belcher Channel, in both of which the ice is known to break up a good deal every summer. It is, therefore, probable that the ice in this eastern sector will experience a certain amount of movement, particularly in the latter part of the summer. If this is so, then the strong currents in Cardigam Strait and Hell Gate must be recognized as a significant contributary cause of ice movements west of Belcher Channel.

Byam Martin Channel occupies a similar marginal position between the ice-bound Hazen Strait and the waterways to the south. Currents are known to exist south of Byam Martin Channel, in both Austin and Byam Channels. As these currents are tidal, they reverse their direction with the ebb and flood of the tide, but observations by the author indicate that their main direction of flow is southwards. Combined with the wind and tide, these currents contribute to the movement of ice between Melville and Bathurst Islands; they also cause it to break up in the southern part of Byam Martin Channel, and in a particularly good year may cause it to move somewhat throughout most of it.

The western part of the enclosed sea apparently remains quite unaffected by these movements of ice beyond its margins. It is known to contain ice many years old, and the uniform appearance of this ice on aerial photographs suggests that it cannot have moved appreciably in recent years, and that it never breaks up. In Hecla and Griper Bay, for example, photographs taken in August 1950 failed to show a single open tide crack; even the closed cracks of former years could be distinguished only extremely rarely and none of these crossed the bay entirely. Though nothing is known about currents in this western part, it seems reasonable to believe that currents are actually present here, if only because of the fact that currents are known to exist within several of the straits bordering on it. Such currents must be quite slight, however, for otherwise there would be a greater tendency for leads to develop, and these would show up on photographs.

SEA ICE

CHARACTER AND DISTRIBUTION

Even the southernmost of the straits and channels that separate the western islands of the archipelago from the continental mainland lie fully 100 miles north of the Arctic Circle; Sverdrup Channel, on the northern outer edge of the region, lies in 80 degrees north latitude, and is thus much closer to the North Pole than it is to any point on the continent. The latitudinal control has, therefore, an extremely important bearing upon ice conditions.

In addition to latitude, however, several other factors also are important. Among the more significant of these are the following: the sizes and shapes of the various straits; the presence of channels and bays; their

directions with respect to the direction of the prevailing winds; the effects of tides and currents upon the ice; and the action upon the ice of fresh water draining off the land.

The principal effect of latitude is to keep the archipelago ice bound throughout by far the greater part of each year. Even the channels along the mainland coast of the continent start to freeze over in the early autumn and remain ice covered until the following July; in an unfavourable year the ice may persist until well into August. Farther north, the period of open water is generally shorter. North of Melville Island, Hecla and Griper Bay and Hazen Strait remain ice covered year after year, and the only open water occurs along an occasional lead that may open and then close again almost immediately.

If the Western Arctic is subdivided on the basis of prevailing type of ice cover in its various water bodies, four main categories can be recognized (*See* Figure 1). The first of these includes all bodies that become free of ice every year; the ice-free period may be only a few days, or it may persist for several weeks. In some years, when conditions have been particularly unfavourable, a little ice may outlast the summer, but even then, as a general rule, the amount of old ice to be found is negligible. Freeze-up produces a uniform covering of young ice that disappears the following year, even though it may have been more than 6 feet thick in the winter. This condition prevails in Amundsen Gulf, the southern part of Prince of Wales Strait, Minto Inlet, Prince Albert Sound, Dolphin and Union Strait, Coronation Gulf, Dease Strait, Queen Maud Gulf, Simpson Strait, and Rae Strait. Bellot Strait and Peel Sound probably fall into this category in favourable years.

The second category includes those water bodies from which the ice clears only partly in a normal summer. In some instances, the ice originating locally may largely disappear, but ice driven by the winds and the currents will come in prior to freeze-up and will become incorporated into the new ice as it forms. Thus, water bodies belonging to this type contain both new ice and ice that is more than a year old. The percentage of new to older ice will vary greatly from year to year, as it will also from one locality to another. During a favourable summer the ice may break up early, whereas during an unfavourable one the break-up may not occur until almost the time of freeze-up. Water bodies belonging to this type include the following: James Ross Strait, Franklin Strait, Peel Sound, Viscount Melville Sound, Barrow Strait, Wellington Channel, McDougall Sound, Austin Channel, Byam Channel, Liddon Gulf, Norwegian Bay, and Belcher Channel.

Several other channels also belong to this type, but are mentioned separately because of their tendency to remain choked with ice throughout the entire summer, even though this ice may become broken up. They, too, will contain both young and old ice, but the latter may be several or many years old, and the former usually does not cover more than a very small part of the whole. Such bodies are: the northern part of Prince of Wales

Strait, Victoria Strait, M'Clintock Channel, Hadley Bay, McClure Strait, Crozier Channel, Kellett Strait, Byam Martin Channel, the unnamed expanse of sea between the Findlay group of islands and Belcher Channel, and probably also Hendriksen Strait and at least the southern part of Sverdrup Channel.

The third type includes those bodies of water that, to all intents and purposes, remain totally covered by ice at all seasons, year after year. Some of these bodies of ice may become largely covered with water on their surfaces, and may even partly break up in certain instances, but because there is no way for the ice to disappear other than by melting in situ, the essential characteristic of a total covering is retained. Such areas are: Ballantyne Strait, Prince Gustav Adolph Sea, Peary Channel, Hassel Sound, Maclean Strait, Hazen Strait, and Hecla and Griper Bay.

The fourth category lies outside the archipelago altogether. This is the true polar pack of the Arctic Ocean. It actually includes several types of ice, ranging from immense ice islands to floebergs, and from ancient palæocrystic ice to young ice, but these differences do not concern us in this study. The polar pack, considered as a unit, is important for three reasons: first, because it presses against the northern edge of the archipelago everywhere eastwards of Prince Patrick Island, even though it does not actually seem to penetrate between the islands; secondly, because it is always found off Prince Patrick and Banks Islands; and thirdly, because the prevailing eastward direction of the current through McClure Strait tends to draw some of this ice into the archipelago in the autumn. This polar pack is constantly in motion; against the northern islands innumerable floes of ice are "pressed against each other under the stress of wind and current, their edges crumble under the terrific strain, and ice pressure ridges are formed resembling mountain ranges in contour, though seldom more than fifty or sixty feet in height"[1].

Even in mid-winter in this area, powerful forces cause cracks to open and then close again. Off Prince Patrick and Banks Islands, where the ice is unhindered by any land obstacle, it tends to move southwards under the pressure of wind and current. The momentum becomes greatest in summer when rivers debouching from the continent have opened the waters along the Arctic mainland coast. The pack then has its greatest latitude for movement, and passes beyond Banks Island opposite Cape Kellett and proceeds westward along the north coast of Alaska.

SUMMER ICE CONDITIONS

One of the dangers of making generalizations about summer ice conditions in the archipelago is that conditions that prevail during one year may be totally unlike those during the next. This is partly due to seasonal changes in temperature, although temperature is only one factor among several that bring about differences in the ice cover. Four of the more important other factors are tides, currents, meltwaters, and winds.

[1] Ibid., p. 8.

Tides cause the ice to break away from the shore, sometimes leaving a narrow or a wide expanse of landfast ice along the shore itself, and sometimes leaving none at all, depending upon whether the foreshore gradient is gentle or steep. On the whole, tides contribute little to the general break-up of the ice in the Western Arctic because their range is small, and hence they are only really effective close to land. Meltwaters are also relatively unimportant, as they reach only the landward edge of the ice.

Currents have a more general effectiveness, but only attain major importance where they are strong. Strong currents delay the formation of a solid ice cover in the autumn; they also prevent the ice from reaching a thickness comparable to that found where currents are weak or entirely absent, and thus contribute to an early break-up the following year. Dolphin and Union Strait is such a locality and, consequently, it generally has a comparatively long season of open water. Strong currents prevail off the southern end of Banks Island and again in the vicinity of Rodd Head, on the northeast-facing coast of this same island. Off Cape Lambton, southern Banks Island, the ice keeps opening and closing throughout the winter, as it does also off Capes Parry and Lyons on the mainland opposite. Cape Lambton is also one of the first places in the archipelago where the ice breaks up in the early summer.

In the archipelago as a whole, winds are the greatest single factor in breaking up the ice. The influence of currents and tides upon the sea ice, and even that of rivers, remains more or less constant from one year to the next. Winds, on the contrary, are extremely variable, not only from season to season but even from day to day. It is virtually impossible to predict, except in a general sort of way, how great or small an effect these winds will have. Not only do they commonly clear a strait of ice one day and fill it up completely the next, but they also can keep a channel that normally clears early in the season filled with ice throughout much of the summer, while emptying another one that usually remains blocked almost until the time of freeze-up. The rapidity with which winds can bring about a complete change in ice conditions is often astounding. Dyer[1] cites one instance when within a period of 36 hours a condition of fairly difficult ship penetration in Norwegian Bay diminished to very little or no ice due to wind action and melting alone.

As a general rule, the straits that separate Banks and Victoria Islands from the continental mainland tend to clear earlier than the channels farther north. From observations made during the summers of 1948 and 1949, the first of which was very favourable for ice conditions and the other extremely unfavourable, it would seem that both Minto Inlet and Prince Albert Sound on the west coast of Victoria Island clear entirely before the ice even commences to break up or move in the nearby Prince of Wales Strait. Yet the dangers of generalizing too much are clearly evident from the following examples of conditions in recent years. First, the break-up

[1] Dyer, J. O.: Polar Ice Reconnaissance As Related to Navigation by Ship in High Arctic Latitudes; United States Weather Bureau, Dept. of Commerce, Washington, 1950.

in Prince of Wales Strait was already well advanced by August 6, 1950, although it had only just commenced on August 26, 1949. It thus suggested the "season" to be earlier by as much as a month. On the other hand, Prince Albert Sound cleared during the first week in August 1949, but was still filled with field-ice on August 6, 1950. During the favourable season of 1948, no ice was observed after July 27 in the channels south of Victoria Island and along the mainland coast to the east. These channels were filled with ice through much of August of the following year, and aerial photos taken in this same region on August 6, 1950, showed ice conditions almost identical with conditions on the same date in 1949. A surprising feature apparent on aerial photographs was the early break-up of the ice in Barrow Strait and in the other bodies of water in the vicinity of Cornwallis Island in the summer of 1950. As early as June 27, 1950, considerable open water existed all around the island; by August 6, Barrow Strait was entirely clear between Cornwallis and Somerset Islands, and both Wellington Channel and McDougall Sound were also entirely open. Thus the 1950 season was apparently much better, in this area at least, than the summer of 1949, for Rae[1] says that in 1949 Resolute Bay, Cornwallis Island, was beset by numerous large blocks of ice during all of the open period.

Temperature cannot be overlooked as a factor that affects ice conditions in the archipelago. This was very clearly demonstrated during 1949. The preceding winter had been relatively mild, and the ice was several inches thinner than usual in both the sea bodies and lakes in the Victoria Island area; consequently, an early break-up was anticipated. Yet, the latter part of May, all of June, and thereafter the balance of the short summer remained very cool all over the Western Arctic; as a direct result, the break-up, instead of being early, occurred fully a month later than in the previous year. The residents at Coppermine, Cambridge Bay, Read Island, and Holman Island all complained that they had "never known so hard a season".

Despite the effects that temperature may have upon the earliness or lateness of the season in the Arctic, its importance for navigation should not be over-rated. In the final analysis, it is primarily the winds that cause some bodies of water to clear, while others remain filled with ice long after break-up. A channel may become entirely free of ice in a matter of hours, even though the ice that is driven from it is still 4, 5, or even 6 feet in thickness; on the other hand, much of this same ice can be driven by the wind into a nearby bay and remain there until it has melted. Stefansson shows the relative unimportance of temperature in comparison with wind in his description of the navigability of the Arctic Ocean off Point Barrow, Alaska. He says that "temperature has practically nothing to do with the navigability. . . . It is entirely a matter of the prevailing winds. When westerly winds blow, the ice is blocked solidly against the land,

[1] Rae: op. cit., p. 103.

while with easterly winds the ice goes abroad, leaving no obstructions to navigation. ....in the summer of 1912, I saw the Polar Sea west of Point Barrow apparently as open as the Atlantic off Sandy Hook—in spite of the fact that the summer of 1912 was the coldest of thirty years"[1].

FREEZE-UP AND BREAK-UP

The difficulty of generalizing about the average dates of freeze-up and break-up and about the duration of the ice-free period, must be obvious from the above discussion. However, there are certain aspects about the change over from winter ice conditions to summer conditions that seem to remain more or less constant despite the great diversity in wind and weather in different years. It is well known, for example, that ice disappears earliest and re-forms most slowly where there is most movement in the water. In certain places where there are strong currents in the Western Arctic, as off Cape Lambton, southern Banks Island, lanes of water may persist all or nearly all winter[2]. In this locality the processes of freeze-up and break-up go on continuously throughout the winter months, and the final spring break-up takes place long before the ice has even started to move in much of the remainder of the archipelago. By the same token, the freeze-up is delayed here until late in the autumn, and the ice continues to break-up and re-form long after the initial freeze. It is for this reason that DeSalis Bay on the south coast of Banks Island has one of the longest seasons of open water of any harbour in the Western Arctic.

It is also well known that once a body of ice commences to break up, it will continue with increasing rapidity. This is partly due to changes in the structure of the ice itself, but other factors may be equally important. For example, once the temperature of the air rises above the freezing point in the early summer, streams commence to debouch off the land and cause rapid melting of the ice at their outlets. The alternate raising and lowering of the water by the tide also acts upon the ice; along some shorelines it may only cause a tide crack to form separating the floating ice from the landfast ice that has become frozen to the bottom, but in other places it may greatly break up the ice near shore. Once broken by tide and weakened by meltwaters and by the summer thaws, the ice becomes crushed and ground into smaller and smaller pieces as a result of the combined action of wind and current. Ultimately, if the season is long enough, it will disappear entirely by melting, although in the meantime it may have been driven far from its place of origin.

As a general rule, small bays tend to clear of ice earlier in the summer than do the straits and channels outside. Thus, at Cambridge Bay, on Victoria Island, the break-up normally occurs in the harbour some time during the latter half of June, although the adjacent strait only commences opening in July, and is frequently not clear of ice until well into August.

[1] Stefansson, V.: My Life with the Eskimo; Macmillan Co., New York, 1919, p. 47.

[2] The long duration of open water off Capes Lambton and Parry is reflected in the movements of the bowhead whale. This was a favourite whaling region in earlier years.

Figure 2. Break-up of the sea ice in Queen's Channel, June 27, 1950. Note that the pans of ice include both young ice (white coloured) and old ice (grey coloured). (RCAF photo.)

In 1947, along the east coast of Victoria Island observers noted that both Greely Haven and Denmark Bay were ice-free on August 1[1] although "M'Clintock Channel....(was) almost completely blocked with ice the entire summer"[2]. Other journals contain many similar references.

Quite commonly, too, rivers find their outlet directly into a strait or channel rather than into the head of a bay. In these places as well, the warm water flowing off the land will clear an expanse of ice away from the river mouth several days or even weeks before the ice starts moving in the strait as a whole. In August 1949 the ice in Prince of Wales Strait was still solid and showed no sign of movement, but a small area of open water was present off the mouth of each stream flowing into the strait from both Banks and Victoria Islands. In many parts of the Western Arctic north of the McClure Strait-Lancaster Sound line, the only open water to be found during the whole of a summer may be confined to places such as these along the coast. For example, on August 20, 1948, there was no sign of the ice breaking up at the weather station at Mould Bay, Prince Patrick Island, but rivers had opened a large expanse of water along the shore in the vicinity of the station. Several days later a new layer of ice 2 inches thick had formed over this opening.

In those parts of the Western Arctic where much ice remains throughout the summer, the temperature of the water near the surface will remain close to 32°F. Even where the sea is open, it is not uncommon to find a water temperature 1 degree to 3 degrees below 32°F. Winds and currents and other lesser factors all encourage thawing of the ice even when the temperature is at, or slightly below, the freezing point for fresh water.

The presence of a large amount of ice keeps the surface of the water relatively calm, thus allowing it to freeze over again at the first opportunity. Where only a little open water exists between the pans or fields of ice it usually remains glassy smooth, and needle-like crystals of new ice can be seen spreading rapidly over its surface even in July and August whenever the temperature of the air at sea-level is close to the freezing point. As a direct result, most of the bodies of water north of the McClure Strait-Lancaster Sound line remain solidly ice-covered every summer, because new ice immediately forms the moment any break in the old ice takes place.

In straits or channels where relatively more open water is to be found, the winds and currents keep the ice constantly in motion, and any new ice becomes broken up almost as soon as it starts to form. Even where ice is mechanically breaking up, new ice can be forming at the same time. The two processes are actually quite independent of each other, so that either the new ice seals the breaks more rapidly than new breaks can open up, or else the ice is being crushed and ground so rapidly that the new needles disappear in the process. Most of the straits and channels in the archipelago,

[1] Task Force 68, 1947; Arctic Circular, vol. 1, pp. 20-22.

[2] Fortier, Y. O.: Flights in 1947 over the Region of the North Magnetic Pole; Dept. of Mines and Tech. Surv., Geol. Surv., Canada, 1948, p. 2.

therefore, belong more or less permanently to one or other of two categories; either they remain almost wholly ice-covered year after year or else they become surprisingly free of ice each summer. A few, however, as M'Clintock Channel, Crozier Channel, Kellett Strait, and Byam Martin Channel, are exceptional; in most seasons they will tend to remain filled with virtually unbroken ice, thus placing them in the first category; in exceptionally favourable years, however, they more nearly fall in the second, for their ice then has a greater tendency to break up than to re-freeze and they may become considerably more open than usual.

Depending upon which of these tendencies prevail in a given locality, it will either freeze over very early or not until quite late in the autumn. Thus, Viscount Melville Sound, which becomes quite largely cleared of ice nearly every summer, does not freeze over until some time during November or December. Stefansson[1] notes that the ice bridge between Melville and Banks Islands does not become available before late December or early January. A further indication of a late freeze-up of the ice in the sound is to be found in the experience of Capt. Kellett's ships, the *Resolute* and the *Intrepid*[2]. These ships were suddenly released from their moorings at Dealy Island on August 17, 1853, when a strong north wind broke up the ice, and they drifted in the pack until November 12, when they became stationary for the winter 30 miles southwest of Cape Cockburn, Bathurst Island.

The freeze-up of small bays and harbours generally takes place before the ice has become solid in the straits outside. This is particularly true when the bays border on such channels as Viscount Melville Sound, but may be much less obvious where they border on small channels where the current is weak, and where the winds are not so effective. McMillan[3] notes that during the stay of the *Arctic* in Winter Harbour, Melville Island, in 1908-09, the harbour froze solidly enough to support a man's weight by September 15, 1908, but that in Viscount Melville Sound outside the ice was still moving on November 7. On the other hand, Cambridge Bay, Victoria Island, normally freezes over some time during the period September 20 to October 1, whereas the nearby straits become solidly frozen over some time in October. Thus in the latter instance the freeze-up of the straits coincides fairly closely with that of adjacent bays, whereas in the former case no such correlation can be made.

Even though wind direction and wind velocity vary considerably throughout the summer, and from one year to the next, they tend to cause the broken floating ice to collect in certain places and to become dispersed from others. In the Western Arctic, the prevailing winds at all seasons of the year have a northerly component; it is reasonable to assume that the strongest winds originate most frequently in the northwest, west-northwest, or north-northwest, for the sastrugi or snow barchans

[1] Stefansson: The Friendly Arctic, p. 493.
[2] Parliamentary Papers; H. M. Stationery Office, London, 1854, pp. 85-98; 1855, pp. 498-641.
[3] Bernier: op. cit., p. 393.

seem almost invariably to be alined at right angles to one or another of these directions. During the summer months, particularly through July and the first half of August, the wind direction varies more than at any other time of the year, yet even at this season the winds have a recognizable tendency to drive broken ice southward and eastward rather than towards the north or west. It is thus not uncommon to find that when the ice breaks up in Viscount Melville Sound, for example, it continues to linger on along the south side of the sound, even though the northern side may be relatively clear. Similarly, ice can be seen hugging the mainland coast in the Amundsen Gulf region while ice-free conditions prevail in the northern part of the gulf. Other things being equal, north-facing bays (even though they may clear of ice before the adjacent straits) commonly fill up again with broken ice once the straits have opened. This ice may linger on until it has melted completely or become frozen into the new ice that forms in the autumn.

It must be understood that the above conditions are merely tendencies, and that it is impossible to establish any general rule that can determine where the ice will collect at any given place or time. The vagaries of wind are many, and the movements of ice are even more unpredictable because the direction and speed of these movements are also influenced by various other factors we have mentioned. On one occasion the ice may be driven by the wind in a direction quite opposite to that of the current; on another, the ice may become pressed so heavily against a shoreline that it requires many days and particularly favourable conditions to dislodge it again. Or again, land and sea breezes may alternately clear a harbour of ice by day while filling it again during the night, and this procedure may occur repeatedly over a period of several weeks. Sometimes, too, the ice seems to be acting completely independently of the wind, a condition that can often be seen where strong currents prevail, or on occasions when the wind direction keeps veering from one point of the compass to another every few hours.

DURATION OF THE ICE-FREE PERIOD

From what has already been said it is to be expected that the earliest break-up and also the latest freeze-up of the ice will occur in open straits rather than in sheltered places along the shore. The least amount of break-up is in some of the northernmost channels. In bays and harbours, on the other hand, intermediate conditions generally prevail. These places commence to open up soon after meltwaters reach them from the land in early summer, but their opening date is later than that of straits where strong currents prevail. Their early freeze-over is one of the first signs that summer is ending, and they are usually solidly frozen before the adjacent straits are ice-covered.

Each bay and harbour is affected by local conditions as well as by more general conditions prevailing in the larger bodies of water in their vicinity. Each bay has a character of its own, which is dependent on its

shape, depth, exposure, and other factors. As a result, even in two adjacent bays, the times of break-up and freeze-up may differ by as much as several weeks, and the length of their ice-free periods may have no similarity whatever. This individuality can be clearly demonstrated by considering two pairs of examples, the northward-facing Castel and Mercy Bays on northern Banks Island, and the southward-facing Winter Harbour and Bridport Inlet on the south coast of Melville Island.

Castel Bay becomes completely free of ice every summer; the last ice apparently disappears in July, and it remains clear until freeze-up. In Mercy Bay, the ice probably starts to break up at about the same time or perhaps a little later, but Mercy Bay rarely or never becomes totally clear. Castel Bay lies only 6 miles west of Mercy Bay, is only a little smaller, and both bays are oriented in the same direction, northwards. The difference seems to lie in the fact that Castel Bay has at its head the outlet of one of the largest rivers in the whole archipelago, whereas Mercy Bay receives the flow from several streams, all comparatively small. Castel Bay is extremely shallow right to its opening into McClure Strait; according to the few soundings made here during the summer of 1948, the depth of water nowhere exceeds about 6 feet. The heavy pack in McClure Strait grounds outside Castel Bay and cannot enter it. When freeze-up occurs at the end of summer, the bay becomes covered by young ice originating at the time of freeze-up. In Mercy Bay, on the other hand, the entrance is deep enough to permit heavy old ice to drift in from McClure Strait, yet the water around the shorelines is in most places so shallow that the heaviest pieces soon become grounded. As these pieces collect, they lessen the chances for escape of any of the bay ice that still remains inside. When freeze-up time arrives in the early autumn, remnants of ice 1, 2, and even 3 years old still persist in the bay. These become cemented together by young ice forming around them. When the whole bay has become solidly frozen, there is no uniformity in either the age or character of its ice cover. Thus even the winter conditions differ considerably in the two places.

A second pair of bays that may be compared are Winter Harbour and Bridport Inlet. Both lie on the south side of Melville Island, and both open southwards into Viscount Melville Sound. Differences in topography that were insignificant in the cases of Castel and Mercy Bays, here are of great importance. At Winter Harbour, the land is everywhere low-lying, and at no point does the gradient towards the interior rise more rapidly than a few feet to the mile. The ground tends to be water-logged, and there are numerous small ponds; yet there are few streams, and these are so small and flow so sluggishly that they have very little effect on the ice in the harbour. Bridport Inlet, on the other hand, has a rock-controlled ridge perhaps 700 feet in height immediately beyond its head. It is bounded on both sides by steep embankments about 300 feet in height, and even has its opening two-thirds closed because of a discontinuous ridge 200 feet in height that crosses it at right angles. Thus it is essentially an enclosed

bay. Winter Harbour, on the other hand, is more open; it widens from a small bay at its head to a broad opening into Viscount Melville Sound. As the ice melts along the shore, because of the insolation and reflection from the land, the lake-like shape of Bridport Inlet permits the remaining ice to have a freedom of movement that is quite impossible at Winter Harbour; and moving ice, of course, breaks up and melts more rapidly than does ice that remains stationary.

Another obvious effect of the difference in topography at these two localities is that Bridport Inlet receives a greater volume of water off the land than does Winter Harbour. Almost equally important is the fact that the meltwaters fan out as soon as they reach Winter Harbour, whereas at Bridport Inlet they are largely retained in the bay because of the peninsula protecting its entrance. Thus in the latter case warm water flowing off the land plays a very appreciable role in melting the ice in the bay, whereas in the former it has much less importance. Bridport Inlet clears of ice during July, whereas Winter Harbour, even though much more exposed to wind action, will seldom clear until some time in August. Once open, both bays can be penetrated by ice from Viscount Melville Sound. Again, however, the peninsula at the entrance to Bridport Inlet serves as a barrier, so that of the two bays Bridport Inlet is the least accessible to this ice. It is known that Winter Harbour becomes frozen over for the winter during mid-September; there is no reason to suppose that Bridport Inlet remains open any longer, although the actual date of freeze-up may differ by a few days between the two places. Winter Harbour is also liable to contain old ice after freeze-up whereas the ice in Bridport Inlet will be entirely, or almost entirely, new, smooth ice.

The above examples illustrate that local factors often have a very important bearing upon ice conditions at the land's margin. The time of break-up may be most affected, or again it may be the length of the ice-free period. Freeze-up time is less influenced, but under certain conditions the closing of the bays may be significantly advanced or delayed.

It is at such coastal places as Mercy Bay and Winter Harbour that a few dates of freeze-up and break-up of the ice in the Western Arctic are being recorded. In analysing these data it should be kept in mind constantly that they may indicate purely local conditions, quite unrepresentative of ice conditions even in the nearby straits and channels.

THICKNESS

Floating ice may take the form of icebergs, floebergs, or ordinary unrafted sea ice. In the latter case it may be the product of the freeze of the previous winter, or it may have been floating for 2 years or more.

There are no icebergs in the Western Arctic, for the reason that glaciers are totally absent. Even those icebergs that have originated from the calving of glaciers from the islands in the eastern part of the archipelago fail to move into its western part, because the prevailing direction of both

winds and currents opposes such a movement. Icebergs are found at only one place within the present study area, at Norwegian Bay, which is a sort of assembling point for the few small icebergs that emege from the fiords of western Ellesmere Island or from Axel Heiberg Island. These bergs are never as large as some of those that originate in Greenland, but they represent the thickest floating ice to be found within the archipelago.

Somewhat more common than icebergs are the floebergs that are formed by the rafting of sea ice under pressure. The actual freezing of water in the archipelago seems to produce ice only 6 to 8 feet thick, but the telescoping of this ice may increase the thickness almost indefinitely. The greatest pressure, and, therefore, the largest floebergs, are found where the pack-ice of the Arctic Ocean presses in upon the outermost of the Parry and Sverdrup Islands. Smaller floebergs may form in any of the enclosed seas or straits, especially in places where there are strong currents, as at Hell Gate and Cardigan Strait, between Ellesmere and Devon Islands, in the eastern part of the archipelago. Within the western part of the archipelago, the largest floebergs seem to be those that sometimes in summer block the northern end of the narrow Prince of Wales Strait. Here, the author observed the ice rafted until its highest point stood 15 or 20 feet out of the water. In the Arctic Ocean, north of Borden Island, however, Stefansson has seen very much larger bergs, as is evident from the following description:

> "I have seldom seen such evidence of pressure and never far from land. The ice was on the average the heaviest I have ever seen and there is no doubt that seventy-five per-cent of it was many years old. But even ice averaging in thickness twenty or thirty feet thick had been crushed up into ridges, which, although not huge as compared to the miniature mountains that may be built out of six and eight-foot ice near land, were still far bigger than any pressure ridges made out of old ice far at sea. The men thought some of them were a hundred feet high. We never measured them, but it is safe to say that they were over fifty"[1].

The western part of the archipelago as a whole is free of floebergs of this magnitude. However, a few masses of thick, heavily hummocked ice originating in the Arctic Ocean or in the Beaufort Sea find their way south with the permanent current off the western sides of Prince Patrick and Banks Islands. Under certain conditions these will be found with the ice in McClure Strait, or will drift into Amundsen Gulf to the south of Banks Island. The only floebergs to be found elsewhere within the archipelago seem to originate locally and are generally much smaller in size. Ordinary unrafted sea ice occupies by far the greatest area of the straits, channels, and bays in the western part of the archipelago. This ice will vary somewhat in maximum thickness from one year to the next. The thermal regime of ice is such that it increases in thickness from the time of its formation in the autumn until early summer, at which time it is at its maximum. Thereafter it becomes gradually thinner again until it breaks up. A table based on Bernier's observations in Winter Harbour during the winter of 1908-09[2] shows this seasonal change (*See* Figure 3).

[1] Stefansson: op. cit., p. 613.
[2] Bernier: op. cit., pp. 343-344.

The maximum thickness the ice attains at any given locality in any one year is influenced first by how early the freeze-up begins in the autumn, second, by the coldness of the winter, and third, by the amount of snow-cover insulation.

Allen[1] points out that studies currently under way seem to indicate that the early development and growth of sea ice is prevented by certain weather conditions that may prevail in October, November, or December. These conditions, he says, may cause the ice that develops later in the season to have a high saline content. This type of ice rots rapidly during the approach of the late spring months and gives rise to a "light ice year", thus opening the navigation season earlier than usual. In the same way that lake ice attains a greater thickness during the course of a winter than does sea ice in the same locality, it follows that any conditions that increase the salinity of this sea ice will also bring about a decrease in its thickness. There is no information of any kind concerning variations in the salinity of the sea water in different parts of the archipelago. It is probable that such variations do exist, however, and that, to a minor extent at least, they affect the thickness of the ice and perhaps the times of freeze-up and break-up.

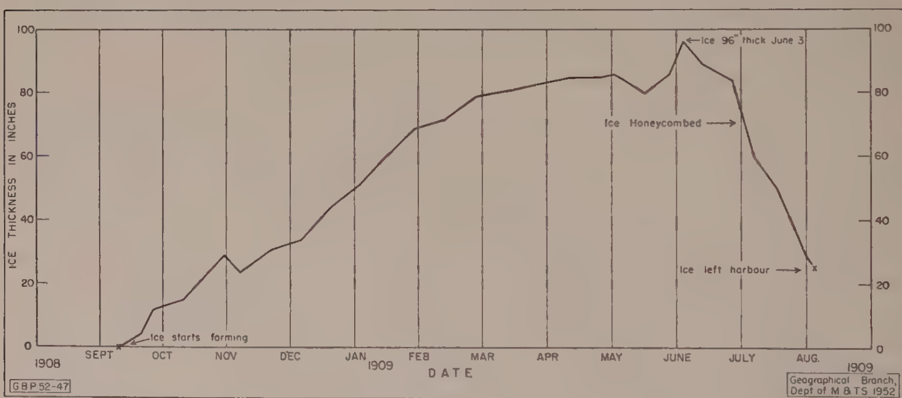

Figure 3. Graph showing the thickness of ice in Winter Harbour, 1908-09, based on Bernier's observations.

In parts of southern Canada, heavy autumn snows sometimes keep ice from thickening normally for the whole of a winter. In the Arctic, however, snow will normally be a rather ineffective insulator. Because the total snowfall is small it seldom attains a depth sufficient to give the ice beneath it more than a slight protection against the exceptionally cold temperatures of the winter months Most snow falls during either the autumn or late spring, and very little falls during the mid-winter period December to March, when the temperatures are at their lowest. Snow

[1] Allen, L. P.: The Geography and Morphology of Sea Ice; United States Navy, Hydrographic Office, Washington, 1950.

in October or November usually remains for the balance of the winter, and to some degree it will retard the rate at which ice thickens, provided it is not blown away by the wind. Heavy snowstorms between mid-April and mid-May will delay further growth just at a time when the ice is about to attain its peak thickness. In neither case, however, is it likely that the snow will lessen the total accumulation of ice by more than a few inches.

In the final analysis, temperature rather than these other factors determines whether the thickness of sea ice will be great or small. The lowest winter temperatures are frequently accompanied by calm weather, a situation that is conducive to the growth of ice. Periods of mild weather, on the other hand, tend to be stormy. Most snowfalls occur during these mild spells, so that a winter characterized by a large number of days with snow is likely to be one whose mean temperature is higher than average. Obviously, a winter that is interrupted by frequent mild spells will not produce the same thickness of ice as will one involving prolonged periods of very low temperatures. During a single winter, sea ice may attain a thickness of 6 to 12 feet, and most of this difference depends upon whether the winter has been abnormally mild or severe.

In the Western Arctic, the thickness of the sea ice reaches its maximum some time between mid-April and the beginning of June. How rapidly the ice deteriorates thereafter depends much on the particular season. If the weather in the latter half of May and during June is abnormally cool, then the ice decreases in thickness more slowly than usual. As a result, break-up can be delayed by as much as several weeks, as happened during the summer of 1949, even though the maximum thickness of the ice that year had been somewhat below average. On the other hand, if a prolonged warm spell occurs during this period, or if the period is abnormally warm, then the surface of the ice will melt rapidly under the direct influence of long hours of sunshine, and the break-up of the ice may be advanced accordingly. Even in the far northern channels, where most or all of the ice remains unmoved from one year to the next, water collects on its surface during the months of June, July, and August to depths varying between several inches and several feet. Close to shore in these northern channels movement on foot will alternate between wading and navigation much of the time because meltwaters flowing off the land greatly augment the water derived from the melting of the ice. Conditions improve a mile or two from land, but even here water tends to collect in pockets or depressions, as between snow barchans for example, and may be deep enough to cause inconvenience in travel.

There are very few observations upon which to base an estimate of the maximum thickness to which sea ice can form during a single winter. Apparently the average is normally about 6 to 8 feet. Amundsen recorded a thickness of 12 feet 6 inches at Gjoa Haven, King William Island, when he wintered there in 1905[1], but that winter seems to have been extraordinarily severe. How severe it was can be imagined from his account of

[1] Amundsen: op. cit., p. 62.

ice conditions during the following summer. At no time during 1906 did the ice break up sufficiently south of King William Island to allow Amundsen to leave Gjoa Haven, yet in a normal year it disappears completely, or almost completely, from this corner of the archipelago. Other records suggest also that Amundsen's 1905 maximum greatly exceeded the average. Armstrong[1] records the thickness of ice in Mercy Bay, northern Banks Island, as 7 feet 8 inches in 1851 and 10 inches less during the following winter. Both 1851 and 1852 appear to have been rather on the severe side. Local inhabitants at Cambridge Bay report that the usual maximum thickness there is about 72 inches, and reports emanating from Resolute Bay, Cornwallis Island, Mould Bay, Prince Patrick Island, and Isachsen, Ellef Ringnes Island, in the early summer of 1948, indicate that the ice thickness at the first place was $69\frac{1}{2}$ inches on April 29, at the second place 72 inches in the latter part of April, and at the third 84 inches on May 14. The Isachsen figure compares closely with Bernier's 1909 observations at Winter Harbour, Melville Island (*See* Figure 3), at which time he found a maximum thickness of 96 inches whereas the other two observations are both a foot less than his April records.

The difficulty of making reliable generalizations from the limited records available is clear from Amundsen's observations from Gjoa Haven:

> "On May 1st (1906) the ice measured six feet in depth, as compared with twelve feet six inches in the previous year. From April 1st to May 1st this year it had decreased nearly an inch, whereas during the same period in the previous year it had considerably increased"[2].

ACCESSIBILITY OF WESTERN ARCTIC WATERS

Oceanographic knowledge about the western part of the Arctic archipelago has its most important applications in the field of navigation. A generation of observations has shown that there has been a diminution in the quantity of drift ice around the fringes of the Arctic Basin, and that this in turn has improved shipping conditions.

Prior to 1946, the only part of the Western Arctic where vessels operated regularly was along the mainland coast to the southwest of the archipelago, in Amundsen Gulf, and through the series of straits that separate Victoria Island and King William Island from the continental mainland. Each summer since 1946, however, two or three vessels have been sent to the five northern Canadian weather stations.

Resolute has been a port of call for the supply ships during each summer from 1947 onwards; Eureka and Alert in the Eastern Arctic have also been visited, but thus far none of the ships have succeded in approaching either Mould Bay or Isachsen. They have not even been successful as yet in reaching Winter Harbour on Melville Island.[3]

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[1] Armstrong, A.: A Personal Narrative of the Discovery of the Northwest Passage; Hurst and Blackett, London, 1857, pp. 524-525.

[2] Amundsen: op. cit., p. 62.

[3] Task Force 68, 1947; Arctic Circular, vol. 1, 1948, p. 3. *See also* Task Force 80, 1948; Arctic Circular, vol. 1, 1948, pp. 90-91; and Supply of Northern Weather Stations; Arctic Circular, vol. 2, 1949, pp. 70-71.

Figure 4. The major categories of ice cover in the Western Canadian Arctic. 1. Unnavigable polar pack. 2. Permanent or semi-permanent ice cover. 3. Permanent or semi-permanent ice cover, susceptible to ice break-up in summer. 4. Subject to ice break-up in summer. 5. Subject to ice break-up in summer, with ice-free areas. 6. Ice-free in summer.

It is now known that a landing can be made every year on Cornwallis Island by vessels approaching it from the Atlantic side. All, or nearly all, harbours on the straits adjacent to the continent west of Boothia Peninsula are equally accessible from the Beaufort Sea. Norwegian Bay is also accessible from the east every year, as is the southern part of Prince of Wales Strait from the west. Viscount Melville Sound can be navigated as far west as Dundas Peninsula, Melville Island, although it may not be possible to make a landing.

Elsewhere, however, it becomes less likely that vessels can navigate so successfully. Much depends upon whether or not a ship's master is prepared to risk getting frozen into the ice and spending the winter in the north. During most years it should be possible to navigate the Northwest Passage by passing between Viscount Melville Sound and Amundsen Gulf via Prince of Wales Strait, but even so the passage through the strait will probably have to be made in September, which allows little enough time to complete the rest of the voyage. In certain unfavourable years, the northern part of the strait seems to remain blocked, thus preventing its use altogether. The only hope of ever getting through McClure Strait is in the autumn. It is always filled with large quantities of ice, but the more favourable the season, the greater becomes the likelihood that heavy polar pack will move into it from the Beaufort Sea. Navigating it successfully in a single season always will be considerably more unlikely than the chance of getting through Prince of Wales Strait. Also because of the polar pack, navigation along the western coast of Banks Island must be normally restricted to shallow-draught vessels, which can proceed cautiously in the shallow water close to the shore. The approach passages to Prince Patrick Island seem virtually impassable, and seem to rule out the possibility of ships being able to reach the weather station located there.

Some of the channels leading through the Parry Islands from Viscount Melville Sound and Barrow Strait open sufficiently to permit a limited penetration northwards. Again, however, the maximum amount of progress will be in September, and as the ship moves away from navigable water instead of towards it, it risks becoming frozen in for the winter before it can extricate itself. Because of permanent impenetrable ice in Hazen Strait, Borden Island and Brock Island lie in the most completely inaccessible corner of the archipelago from the point of view of reaching them by ship. The weather station at Isachsen may be equally inaccessible, even though ice conditions in the approach passages to it are not likely to be quite as severe as they are in Hazen Strait. Nevertheless, Isachsen's report[1] that "there had not been open water for a long time" along the entire west coast of Ellef Ringnes Island is quite significant.

[1] Sverdrup, O.: New Land: Four Years in the Arctic Regions, Vol. II; Longmans, Green & Co., London, p. 297.

The one island of all the far northern group in the western part of the Arctic that might be reached in favourable years is Meighen Island. Here, once again, September is the crucial month, and the risks are the same.

Ice remains today, as formerly, a great barrier to navigation, and in spite of modern physical and technological improvements some parts of the archipelago remain as inaccessible to our present day vessels as they were to those of the past.

RÉSUMÉ

Cet article traite de la géographie des eaux de l'Arctique occidental canadien, soit des eaux des détroits, bras de mer et canaux qui entourent les îles situées à l'intérieur des limites suivantes: à l'est, la zone est limitée approximativement par le 95ième degré de longitude ouest mais inclut les îles de Cornwall, Cornwallis et Somerset entièrement et exclut l'île de Devon, au sud, par les détroits et canaux qui séparent l'archipel de la terre ferme, enfin, à l'ouest et au nord par la mer de Beaufort et l'océan glacial arctique.

Un nombre restreint de sondages nous révèlent que toutes les îles de cette partie de l'Arctique reposent sur le prolongement nordique de la plate-forme continentale nord-américaine. Des preuves de submersion nous font déduire que cette plate-forme a été abaissée et l'est encore.

L'amplitude des marées est très faible dans les eaux de l'Arctique occidental. Les marées ont deux cycles par jour et l'intervalle entre les phases successives devient de moins en moins constant vers l'est. L'inégalité diurne dans l'amplitude de la marée est caractéristique en plusieurs endroits.

L'un des princiapux courants est celui qui prend naissance dans la mer de Beaufort, traverse l'archipel en passant par les détroits de McLure et de Melville et meurt dans la baie de Baffin. Les courants locaux, qui existent, peut-être, dans la plupart des canaux et détroits de cette partie de l'Arctique canadien, changent de direction avec les marées, se dirigeant tantôt dans un sens, tantôt dans un autre. Dans certains cas le mouvement de ces courants est visible, tandis qu'en d'autres cas les conditions locales nous empêchent de les discerner.

Toutes les mers, détroits et canaux de l'Arctique occidental sont recouverts de glace durant la majeure partie de l'année. Cependant les canaux les plus au sud se libèrent de glace pendant une brève période tandis que les canaux du nord sont rarement, voire jamais ouverts. Le vent, semble-t-il, est le plus important facteur déterminant les différences considérables qui existent d'un endroit à un autre et d'une saison à une autre dans la dissolution de la glace de mer.

La glace nouvelle qui s'est formée au cours d'un seul hiver, peut atteindre une épaisseur variant de moins de six pieds à environ douze pieds selon la froidure du climat; généralement elle atteint entre six et huit pieds. Une glace plus vieille peut avoir une épaisseur considérable, surtout si elle est empilée.

On peut utiliser le passage du nord-ouest presque à chaque année maintenant, à condition de suivre la route la plus favorable. Le temps à prendre pour naviguer à travers certains canaux doit être calculé d'une façon précise, car ils sont ouverts à la navigation pendant quelques jours ou quelques heures de l'été seulement. Les canaux au sud de l'île Victoria sont ouverts à la navigation chaque été, mais cette saison de navigation varie d'un été à l'autre. Quelques-uns des canaux les plus au nord demeurent impénétrables d'année en année.

MAP NOTES

Selected Canadian Maps

Canada. 1:6,336,000 or 100 miles to 1 inch.

Canada, Dept. of Mines and Technical Surveys, Surveys and Mapping Branch, Ottawa, 1951. Price 50 cents.

This is the most recent political map of Canada, representing an entirely new compilation on a Lambert Conformal Conic Projection with standard parallels 49°N. and 77°N. and with a modified Polyconic projection north of latitude 80° to the North Pole. It, therefore, gives a truer picture of the whole country on one single sheet 34 inches high and 37½ inches wide. Printed in seven colour tints the map shows the approximate limit of permanent polar ice, the railways in red, and the Alaska and Mackenzie highways by means of a double red line.

Canada. 1:2,217,600 (35 miles to 1 inch).

Canada, Dept. of Mines and Technical Surveys, Surveys and Mapping Branch, Ottawa, 1952 (4 sheets). Price $3.

This map is an enlargement of the new 100 mile map of Canada. It is reproduced in both black and white, and in black and water blue, the latter also showing the principal railways and the Alaska and Mackenzie highways in red. Each of its four sheets measures 40 inches in height and 52 inches in width.

Water Powers of Canada. 1:6,336,000 or 100 miles to 1 inch.

Canada, Dept. of Resources and Development, Engineering and Water Resources Branch, Ottawa, 1952.

This is a revised edition of the 1951 blue-line print noted in Bulletin No. 2. As before, developed and undeveloped water power sites are shown in circles in proportion to the horsepower capacity of the sites, graded from "1000 h.p. or under", to "above 2,000,000 h.p.". This edition shows the latest developed water power sites in the Mattawa region of the Ottawa Valley; in the Lake St. John and Baie Comeau areas of Quebec; in Labrador; and in the Vancouver and Trail areas of British Columbia.

Alberta, Palæozoic Topography and Formations. 1:1,013,760 (16 miles to 1 inch).

Alberta Dept. of Mines and Minerals, Edmonton, 1951.

Prepared from information compiled by the Petroleum and Natural Gas Conservation Board, this map is printed in eight colours on a base showing townships and ranges. Boundaries of each type of geological formation are shown. with a comprehensive explanatory legend. Defined and assumed contouring is indicated with contour intervals of 100 feet. No information is given for the northern part of the province except for a small enclave on Peace River.

Province of Alberta, Resources and Development. 1:1,367,200 (20 miles to 1 inch).

Alberta, Queen's Printer, Edmonton, with the collaboration of the Calgary Power Limited, Industrial Development Department, 1952.

This most recent resources map of Alberta is printed in five colours. Surface and mineral resources areas are indicated by name, with those that have been developed underlined, or by circles covering areas in which they occur. Oil and gas pipe-lines and transmission lines are shown in colour. Boundaries of forest reserves, irrigation and mining areas, and national parks are also indicated, together with main highways, railways, and airways.

Tectonic Map of Canada. 1:3,801,600.

The Geological Association of Canada, with the support of the Geological Society of America, 1950 (2 sheets). Price $3.

This map was prepared from base map No. 820A of the Geological Survey of Canada. Compilations were made from maps published by the Geological Survey of Canada, and by the various provincial Departments of Mines, together with mining and oil companies. The map is a multicolour that shows both structural features and geology for the whole country north to 74 degrees, with an inset of the Arctic islands on a scale of 100 miles to 1 inch. Structural features include faults, folds, and related structures, and structure contours (sub sea-level).

[E.L.B.]

BOOK NOTES

Recent Government Publications of Geographical Interest

Canada Descriptive Atlas. Canada, Dept. of Citizenship and Immigration, Ottawa, 1951. Price $1.

This is the latest revision of the publication that has appeared from time to time under the same title. Designed for intending immigrants, it gives a brief description of all aspects of Canada as a whole, followed by one for each of the provinces. The textual material is illustrated by photographs and a map of the area concerned. Of the 100 pages, 24 are occupied by the maps, which are multicoloured and on scales varying from 27 to 200 miles to 1 inch, depending on the size and shape of the political area involved. Each of them shows political boundaries, railways, settlements, and the major rivers and lakes, with an overprint in red indicating the approximate location of major natural resources and economic activities.

[N.L.N.]

Bibliography of Periodical Literature on Canadian Geography for the Period 1940-1950. Canada, Dept. of Mines and Technical Surveys, Geographical Branch, Biblio. Ser. No. 9, Ottawa, 1952, pp. ix-128. Price 50 cents.

This aid to geographical research lists items according to Canada as a whole, the sections of Canada, the individual provinces, and special topics such as the Great Lakes–St. Lawrence Waterway. Within these major divisions, items are listed alphabetically according to the systematic topic with which they are concerned.

[N.L.N.]

A Bibliography of Canadian Plant Geography—IX, The Period 1941-1945. By Harold A. Senn. Canada, Dept. of Agriculture, Ottawa, 1951, pp. 1-183.

Le neuvième volume de cette bibliographie, paru en décembre 1951, porte sur la même extension géographique que le précédent, c'est-à-dire le Canada, le Groenland, St-Pierre et Miquelon et l'Alaska. En plus des ouvrages parus entre 1941 et 1945, on y mentionne 105 travaux additionnels pour la période 1635-1940. Comme par le passé, on trouve dans cette bibliographie un index des noms de lieux et un index des sujets.

[P.G.]

Canada 1952. The Official Handbook of Present Conditions and Recent Progress. Canada, Dept. of Trade and Commerce, Dominion Bureau of Statistics, Ottawa, 1952, 312 pp. Price 25 cents.

This publication, which started in 1930, is a supplement to the Canada Year Book, adapted for teachers, pupils, and Canadian citizens generally. It offers a brief and attractive record of current physical, political, economic, and social conditions of the country.

Each issue contains leading special articles; the 1952 edition presents two of these articles: "Canada in the Chemical Age" and "Canada's Defence Program".

[P.C.]

CANADIAN DEPOSITS OF URANIUM AND THORIUM. By A. H. Lang. Dept. of Mines and Technical Surveys, Geological Survey, Canada, Paper 51-10, Ottawa, 1951.

This is a preliminary report on Canadian deposits of uranium and thorium. In Part I of the report, the author gives an outline of the history of prospecting and mining for uranium in Canada and a summary of regulations of the Atomic Energy Control Board. Part II contains generalizations about the mineralogy of such deposits, types of occurrences, their geological setting and geographical distribution, and the economics of uranium mining. Part III is a description of areas in which uranium deposits occur.

[P.C.]

CANADIAN AGRICULTURE AT THE MIDDLE OF THE CENTURY. By J. F. Booth. Economic Annalist, vol. XXI, No. 3, June 1951, pp. 53-58.

This is a summary of the contributions of experimental and scientific research in the field of agricultural science in Canada during the last half century. Intensive research and study have resulted, among other things, in the discovery of new varieties of wheat, in new knowledge for the control of plant and animal diseases and the control of insect pests, and in better methods of soil cultivation, conservation, and farm management. In spite of the long strides taken in 50 years, the need for research in the future is greater than ever.

[M.R.D.]

CANADA'S FORESTS 1946-1950—REPORT TO THE SIXTH COMMONWEALTH FORESTRY CONFERENCE HELD IN CANADA 1952. Canada, Dept. of Resources and Development, Ottawa, 1952, 49 pp.

Travail embrassant brièvement toutes les phases du développement, de l'exploitation et de l'industrie de la forêt au Canada. L'étude est divisée en cinq chapitres principaux traitant de la forêt dans l'économie canadienne, de la politique et de l'aménagement des forêts dans l'après-guerre, de l'exploitation, de la recherche et de l'éducation forestière, et de la main-d'œuvre employée à cette industrie. Seize tableaux de statistiques dans le texte, dix tableaux en appendice et une carte de la classification des forêts canadiennes complètent ce compte rendu.

[P.G.]

A BRIEF HISTORY OF MAPPING IN CANADA. By J. C. Hay and R. D. Davidson. The Canadian Surveyor, vol. X, No. 9, July 1951.

This summary presents in outline the history of mapping in Canada from the achievements of the early explorers of the 16th century to the work of later French and British explorers and traders. An account of official Canadian mapping during the last 100 years is presented in detail. It traces the development of organized mapping to the present day, stressing legal surveys under the Dominion Land Survey system and military surveys under the Department of National Defence.

[B.V.G.]

THE PREPARATION OF VISIBLE AREA MAPS BY FIELD SKETCHING. By R. W. Chorlton. Canada, Dept. of Resources and Development, Forestry Br., Forest Research Div.; Forest Fire Research Note No. 16, Ottawa, 1951, 16 pp., sketches, diags., biblio.

The object of this paper was to provide factual information and methods on the preparation of visibility maps designed for planning a detection system for forest fire control. The author does not set out to present new information, but rather to assemble the work of many other investigators in a brief, compact, and concise way.

After a short and critical examination of the four main methods used in this mapping (the profile, relief model, photographic, and field sketching), the author deals in detail with the field sketching method, which is considered the only one that can be adopted in mapping visible areas in many parts of Canada where only planimetric maps are available.

The nucleus of the paper deals with problems directly connected with forest fire control, the calculation of tower heights, and detailed map analysis, through which the final results, the best co-ordinated coverage of areas of high risk and hazard, could be obtained with a minimum number of installations of control points.

Well-drawn sketches and diagrams and a carefully selected bibliography add greatly to the value of this booklet.

[R.T.G.]

PRINCIPAL SYMBOLS, PATTERNS AND COLOURS IN COMMON USE ON GEOLOGICAL MAPS AND FIGURE ILLUSTRATIONS. Canada, Dept. of Mines and Technical Surveys, Geol. Surv. of Canada, Ottawa, 1951, 21 pp., illus., sample maps.

In this booklet careful consideration has been given to the problem of standardization in the use of symbols, patterns, and colours for geological maps and figure illustrations, and in its compilation the Geological Survey of Canada has incorporated recommendations of various Provincial Departments with regard to this subject.

The first part concerns symbols used on geologic maps, with a complete set of symbols for maps showing oil and gas data. The second part deals with samples of conventional patterns used on blue-line maps, black and white maps, and figure illustrations to depict sedimentary, volcanic, intrusive, and metamorphic rock formations. The suggested patterns are based mostly on the existing zip-a-tone mechanical patterns, as well as on specially designed and hand-drawn patterns. The third part covers principal colours and colour combinations for lithographed geological maps. Suggested colour charts useful for small-scale maps of large regions are shown for Cenozoic, Mesozoic, Palæozoic, Precambrian, and Intrusive rocks.

The booklet is not intended to serve as a complete guide in the preparation of all geological maps and figure illustrations especially on large-scale and detailed maps where little standardization in colour is possible, but to provide a basis of reference where standardization of various principal symbols, patterns, and colours is required.

[R.T.G.]

A BIBLIOGRAPHY ON SNOW AND ICE. By D. C. Pearce. Canada, National Research Council, Ottawa, 1951, 69 pp. Price 75 cents.

This compilation includes references to articles on snow and ice and related topics that have been published in a group of Canadian periodicals and institute transactions up to December 1950. They are classified under broad subject groups, by source in chronological order, and by author. This bibliography is a useful reference to the basic research on snow and ice that has been published in Canada.

[J.K.F.]

MINERAL INDUSTRY OF DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES. By C. S. Lord. Dept. of Mines and Technical Surveys, Geol. Surv., Canada, Mem. 261, Ottawa, 1951, 336 pp., maps, diags., illus. Price $1.25.

This report was first published in 1941 and has now been revised to include later developments. It concerns the only district of Northwest Territories in which significant mineral production has taken place. Dr. Lord first outlines the physical and economic factors affecting the mineral industry and then describes in detail most of the mining properties in the district. An extensive bibliography completes the memoir.

[J.K.F.]

THE CANADIAN SNOW SURVEY 1947-1950. By D. C. Pearce and L. W. Gold. Canada, National Research Council, Tech. Memo. 21, Ottawa, 1951, 34 pp., map, illus., graphs, tbls.

The measurement of the physical properties of snow on the ground at exposed locations at twelve stations across Canada was carried out each winter from 1947 to 1950 and observations are being continued at six of these stations for an indefinite period.

This summary of observations includes a description of each of the stations and the instruments designed especially for the survey; a classification of snow types; the procedure followed; and analyses of the snow conditions at each station.

Climatic summaries of each station are appended, as well as charts showing monthly snow surface and weather data for Resolute, N.W.T. Clear photographs illustrate the special measuring equipment.

[J.K.F.]

SOUTHAMPTON ISLAND. By J. Brian Bird. Canada, Dept. of Mines and Tech. Surv., Geog. Br., Mem. 1, Ottawa, 1953, 84 pp., maps, illus., biblio., index. Price 50 cents.

This memoir summarizes the field observations made by the author and his colleagues during the summers of 1950 and 1952. In addition, it sets forth the known findings of other observers, whether explorers, scientists, traders, or natives.

The introduction includes a summary of early work, beginning with Button in 1612, as a prelude to the systematic physical geography of the island. This is followed by a regional description, and the fourth chapter is concerned with human geography, with emphasis on the past and present settlement patterns.

The memoir is illustrated with 19 maps and diagrams and 15 photographs of some of the main physical features of the island.

[N.L.N.]

OCEANOGRAPHIC DATA OF THE WESTERN CANADIAN ARCTIC REGION, 1935-37. By J. P. Tully. Jour. Fisheries Research Bd. of Canada, vol. 8, No. 5, 1952, pp. 378-382, maps, tbls.

This is an assessment of the hydrographic observations made by the R.C.M.P. patrol vessel *St. Roch*. Tables are included for 1935 and 1937, giving surface sea-water temperatures and salinities, and these figures have been plotted on maps of the area. Oceanographical information regarding these Canadian waters is scant and, though necessarily limited in its conclusions, Mr. Tully's summary is a valuable beginning in the study of the western Arctic waters.

[J.K.F.]

ALASKA HIGHWAY—CANADIAN SECTION. Canada, Dept. of Resources and Development, Can. Govt. Travel Bureau, Ottawa, 1952, 14 pp., map, photos, tbls.

The Canadian Government Travel Bureau has included in this short pamphlet virtually all necessary information for travellers on the Canadian section of the highway. Included are: the various Federal and Provincial Government regulations concerning entry, prospecting, hunting, and fishing, etc.; a brief outline of weather conditions; a detailed list of accommodations. Also included are additional government agencies, both American and Canadian, which can supply any further information required.

[B.C.]

CLIMATE IN THE COASTAL SEAS OF BRITISH COLUMBIA. By J. P. Tully. Progress Reports of the Pacific Coast Stations, No. 90, Fisheries Res. Bd. of Canada, March 1952, pp. 16-20.

The climate of the sea is determined by the annual changes in its temperature and salinity. In this article three general climatic types have been drawn up, using these two factors and based on the meteorological data from a number of stations on the British Columbia coast.

The first of these climatic zones is an oceanic one with nearly constant ocean temperatures and salinity, and the remaining two are coastal climates, the one having lowest salinity in winter because of direct runoff and the other having lowest salinity in late spring and early summer because of the effect of stored runoff.

A map of the marine climate regions is included, together with graphs showing the annual temperatures and salinities for twelve coastal stations.

[R.H.D.]

Daily Sea-Water Observations Along the West Coast of Vancouver Island. Progress Reports of the Pacific Coast Stations, Fisheries Res. Bd. of Canada, No. 86, April 1951, pp. 6-11.

The most favourable environment for fish life in the deep ocean waters is defined by the temperature, salinity, and currents. In order to obtain this information, a number of ships have been outfitted and surveys conducted. In addition, since 1936, daily sea-water observations have been made at three lighthouses on the west coast of Vancouver Island. This article discusses the sites of the three stations and some of the findings that have been made. There are several photographs of the lighthouses, a map of their location, and a graph with statistics for a sample year showing salinity and temperature at all three stations .

[R.H.D.]

The Crab Fishery off Graham Island, British Columbia, to 1948. By Robert G. McMynn. Canada, Dept. of Fisheries, Fisheries Res. Bd. Bull. 91, Ottawa, 1951, 21 pp., figs., photos., tbls. Price 25 cents.

As a result of fluctuations in the annual production of crabs from the Queen Charlotte fisheries, the Fisheries Research Board in 1947 undertook a study of the area. The results are presented in this report, together with a brief historical sketch and descriptions of the fishing grounds, methods, and canning processes.

[B.C.]

Post-War Development of Bushland Farms in Northern Alberta. By K. Elgaard. Economic Annalist, vol. 22, No. 2: 32-35, April 1952, tbls.

In 1945 and in 1951, the Economics Division of the Federal Department of Agriculture made identical surveys of thirty-seven farms in the vicinity of Athabasca, Alberta. This report briefly summarizes the results of these two studies, which show increased size of farms and increased acreage of improved land. Statistical tables show graphically the average sizes of farms, number of livestock, average net worth, and average cash receipts of the farms surveyed.

[B.C.]

The Conservation of Soil Moisture in Southern Saskatchewan. By W. J. Staple and J. J. Lehane. Scientific Agriculture, vol. 32, No. 1, Jan. 1952, pp. 36-47. Price 25 cents.

As a result of 7 years' measurement of moisture conservation on substations in south-western Saskatchewan, this paper shows the advantage of stubble summer-fallowed fields in conserving winter precipitation, that during the summer months showers must be fairly heavy or frequent in order to penetrate below the evaporation zone, and that weed growth causes large losses of soil moisture during the summer-fallow period. It is, therefore, an aid in evaluating the efficiency of the practice of summer-fallowing to control weeds and conserve moisture in a semi-arid environment.

[N.L.N.]

Preliminary Report on Copper, Nickel, Lead and Zinc Deposits of Ontario. (2nd. Edn., May 1952.) By Jas. E. Thomson. Ontario, Dept. of Mines, Toronto, 1952, 21 pp., tbls.

This publication follows a preliminary report printed in 1950, but incorporates much new information that has since become available. The widespread search for non-ferrous metals in this province in the past 2 years has been so productive that the final report containing maps has been delayed until a more opportune moment. The author has omitted some of the less important properties present in the first report, but he includes most new discoveries.

The information, which is divided into two main categories of (1) copper and nickel deposits and (2) lead and zinc deposits, is given in tabular form. These tables show the name, location, ownership, and development of the properties. The descriptions of the geology, orebodies, and production are included, with references and remarks.

[J.K.S.]

GAZETTEER OF CANADA, SOUTHWESTERN ONTARIO. Ottawa, Canadian Board on Geographical Names, 1952. Queen's Printer, Ottawa. Price 50 cents.

This is the first volume of a new Gazetteer of Canada Series being published by the Canadian Board on Geographical Names. The purpose of the series is to provide a key to the location of all populated places and geographical features in Canada. The items are listed alphabetically, the type of feature is given, e.g., hamlet, station, channel, rock, and its general location and exact geodetic position.

As it has in the past been difficult to locate places and features in Canada, this series of gazetteers is particularly welcome. This first volume is devoted to southwestern Ontario, because this area is more completely covered by large scale maps than any other part of Canada.

[R.H.D.]

CHANGES IN AGRICULTURE IN DUNDAS COUNTY, ONTARIO. By J. A. Dawson. Canada, Dept. of Agriculture, Marketing Serv., Economic Div., Ottawa, 1952, 6 tbls.

This paper is a study of changes taking place in agricultural practices on 111 farms in Dundas county, visited in 1917 and again in 1948, thus providing a basis for noting the changes that took place in the 30-year interval. During this period, crop acreage and total amount of livestock remained the same. Within this framework, however, emphasis turned from horses to young cattle, from hogs to poultry, and in crops from oats to hay and pasture. The total grain acreage was reduced, but there was a subsequent increase in purchase of feed. The most striking change was the shift to more mechanized farming, resulting in a rise in total investment per farm. Thus individual operators became more vulnerable to price changes and marketing factors.

[M.R.D.]

UPPER THAMES VALLEY CONSERVATION REPORT. Ontario Dept. of Planning and Development, Toronto, 1952, approx. 420 pp., illus., dgms., maps.

This is another in the series of conservation reports on the drainage basins of Ontario (*See* Moira Valley Conservation Report, *Geog. Bull.* No. 2). Basically a revision and expansion of a similar report issued in 1946, it embodies the results of a re-survey of the area made in 1950 in accordance with the improved methods developed in the preceding 4 years. It is over 400 pages long, and even at that excludes the history of the Upper Thames Valley, which is to be issued as a separate volume.

This first volume, therefore, is devoted mainly to aspects of the physical geography of the upper section of the Thames basin and covers land use, forestry, water, wild life, and recreation. Each of these sections is illustrated with photographs, diagrams, and maps, and accompanying the report as a whole are four multicoloured maps in sections: Thames Valley Park (about 1,500 ft. to 1 inch); Biological Conditions of Streams (about $2\frac{1}{2}$ miles to 1 inch); Recommended Land Use (about $1\frac{1}{4}$ miles to 1 inch); and National Water Storage areas, Reforestation Land, and Existing Woodland (1 mile to 1 inch).

[N.L.N.]

REPORT ON LAKESHORE EROSION; PART I, LAKE ONTARIO FROM NIAGARA TO COBOURG. By G. B. Langford. Ontario, Dept. of Planning and Development, Toronto, 1952, 36 pp., graphs, tbls.

This well-written report illustrates the need for governmental acceptance of responsibility in measures to combat shore erosion. Professor Langford also points out that the most important causes of changes in lake level are the natural ones of precipitation and evaporation, which may result in raising or lowering the level by a foot or more in a single year. "Compared to this, the man-made or artificial causes of change are quite insignificant, amounting as they do to a total rise of only 6 inches". The author lists and describes the various types of protective works along lake shores and the natural factors affecting their usefulness and resistance.

[J.K.F.]

THE MINING INDUSTRY OF THE PROVINCE OF QUEBEC IN 1950. Quebec Dept. of Mines, Quebec, 1952, 87 pp.

Il s'agit du rapport annuel du Ministère des Mines de la Province de Québec pour l'année 1950. On y présente les principaux événements dans le monde minier de cette province ainsi que les données statistiques les plus récentes. Ce rapport est divisé en deux parties: 1° une revue générale de la production, 2° une description des opérations minières.

Cette deuxième partie se subdivise à son tour en deux sections; l'une est consacrée à une dizaine de métaux et l'autre traite des minéraux non métalliques, soit les minéraux industriels et les matériaux de construction. Dans la section sur les métaux, on y a inclu un résumé chronologique des développements du minerai de fer dans le Nouveau-Québec.

[P.C.]

SURFACE WATER SUPPLY OF CANADA. ATLANTIC DRAINAGE. Dept. of Resources and Development, Water Res. Paper 108, Ottawa, 1952, 166 pp., 1 map, tbls. Price $1.50.

This report presents the results of hydrometric investigations in the provinces of Nova Scotia, New Brunswick, and Newfoundland for the climatic years 1948-49 and 1949-50.

It is one of a series of similar reports containing current hydrometric data for the Atlantic Drainage division of Canada. Part I of the report is concerned with the administrative and technical aspects of carrying out the surveys; Part II, gives the detailed hydrometric data; Part III gives meteorological data; Part IV contains a reference list of water records; and Part V is an index for the report.

[W.A.B.]

CURRENT MEASUREMENTS IN THE GRAND MANAN CHANNEL. By D. G. MacGregor and H. J. McLellan. Joint Committee on Oceanography, St. Andrews, N.B., 1951, 13 pp., diags., tbls.

During October 1950, current measurements in the Grand Manan Channel using a geomagnetic electro-kinetograph added considerably to the recorded data for this body of water. It was found that shoreline and submarine configurations have a marked effect on current patterns and that the strongest currents occurred during ebb tide in a southerly direction.

Tables, plots of current vectors, and a bibliography add to the usefulness of this report.

[J.K.F.]

REPORT OF THE COMMITTEE ON FORESTRY AND NATURAL RESOURCES. New Brunswick, Legislative Assembly, Fredericton, 1952, 62 pp., map, illus., tbls., mimeo.

The New Brunswick legislature has sponsored since 1947 a Committee on Forest and Natural Resources. The report of their annual deliberations is a compilation of various briefs and papers presented by specialists from government, industry, and education.

An investigation sponsored by the Committee undertook a study of the Small Tree Act of Nova Scotia "with a view to the consideration of legislation calculated to protect all forest and land from improper cutting". The report of this investigation traces the development of such legislation, shows how it is administered, and evaluates the effects upon the forests, lumbering industry, and public interest. Other submissions summarize the work of New Brunswick's Travel Bureau in promoting its tourist trade, outline the ways in which the Federal Department of Fisheries administers the provincial fishery resources, and discuss the functions of the Canadian Wildlife Service. The program of forestry instruction in regional schools of the province is described, and a paper on woodlot management for privately owned land included. Still other papers are concerned with artificial versus natural regeneration in forestry, the condition of Crown land in Kent county, the commercial fisheries of New Brunswick, a report on game laws and hunting and fishing activities, and, finally, a summary including a final report with recommendations from the Committee.

[J.K.S.]

THE RECLAMATION OF TIDAL MARSHLANDS IN THE MARITIME PROVINCES OF CANADA. Canada, National Research Council, Tech. Memo. 23, Ottawa, May 1952.

This short paper discusses some of the technical problems encountered by the Maritime Marshland Rehabilitation Administration in the marsh lands surrounding the Bay of Fundy.

The process of silting is briefly described, the functions of dykes and aboiteaux (structures to prevent the inflow of tidal water up stream beds) discussed, and the engineering problems stated. Within the last decade modern equipment has been used, but the methods of control are still fundamentally those employed by the early French settlers.

A short discussion follows the main presentation.

[M.H.M.]

SOIL SURVEY OF PICTOU COUNTY. By D. B. Cann and R. E. Wicklund. Nova Scotia Soil Sur. Rept. 4. Canada, Dept. of Agriculture, Expt. Farms Serv. and Nova Scotia Agr. Coll., Truro, 1951, 66 pp., tbls., illus., maps.

SOIL SURVEY OF PRINCE EDWARD ISLAND. By G. B. Whiteside. Canada, Dept. of Agriculture, Expt. Farms Serv. and Prince Edward Island Dept. of Agriculture, 1950, 83 pp., tbls., illus., maps.

These soil survey reports on Pictou county and Prince Edward Island continue the well-known series of soil surveys being made on a Federal-Provincial basis. The first is the fourth devoted to Nova Scotia and gives a general description of the area, together with chapters on the factors affecting soil formation in Pictou county, and agriculture. Part III, however, forms the core of the work, in which a classification and description of the soils is given. The soils are first grouped according to their parent materials and within these major groups they are described by their associations. Photographs are used to illustrate the features of many of these and the whole report is further illustrated with five sketch maps and a soil map in colour of the whole county on a scale of 2 miles to 1 inch.

The report on Prince Edward Island is on similar lines, but is unique in that it covers a whole province. There are, however, three coloured soil maps, one for each county, again on a scale of 2 miles to 1 inch. Also included is a table of the natural vegetation characteristic of the island.

[N.L.N.]

TAIWAN (FORMOSA)—A GEOGRAPHICAL APPRECIATION. Canada, Dept. of Mines and Tech. Surv., Geog. Br., For. Geog. Inf. Ser. No. 5, Ottawa, 1952, 59 pp., maps, tbls., illus. Price 50 cents.

Taiwan may well become a major point of interest in the Far East and this report is designed to acquaint Canadians with the extent and limitations of the human and material resources of the island considered in the light of its cultural achievements.

The text is illustrated with 23 maps and diagrams and supplemented with extensive bibliographies of maps and books.

[N.L.N.]

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